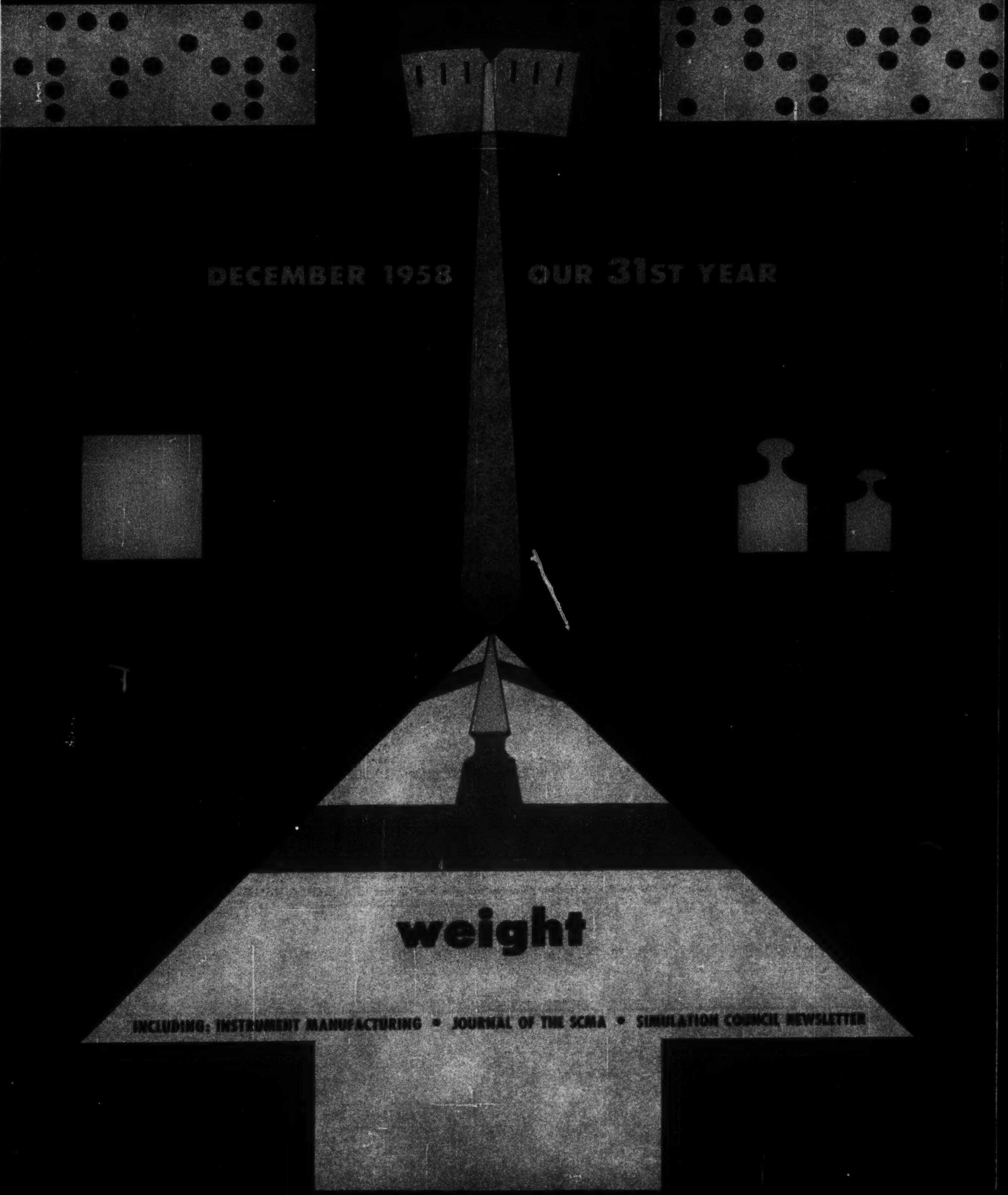
INSTRUMENTS AND AUTOMATION

DECEMBER 1958 OUR 31ST YEAR



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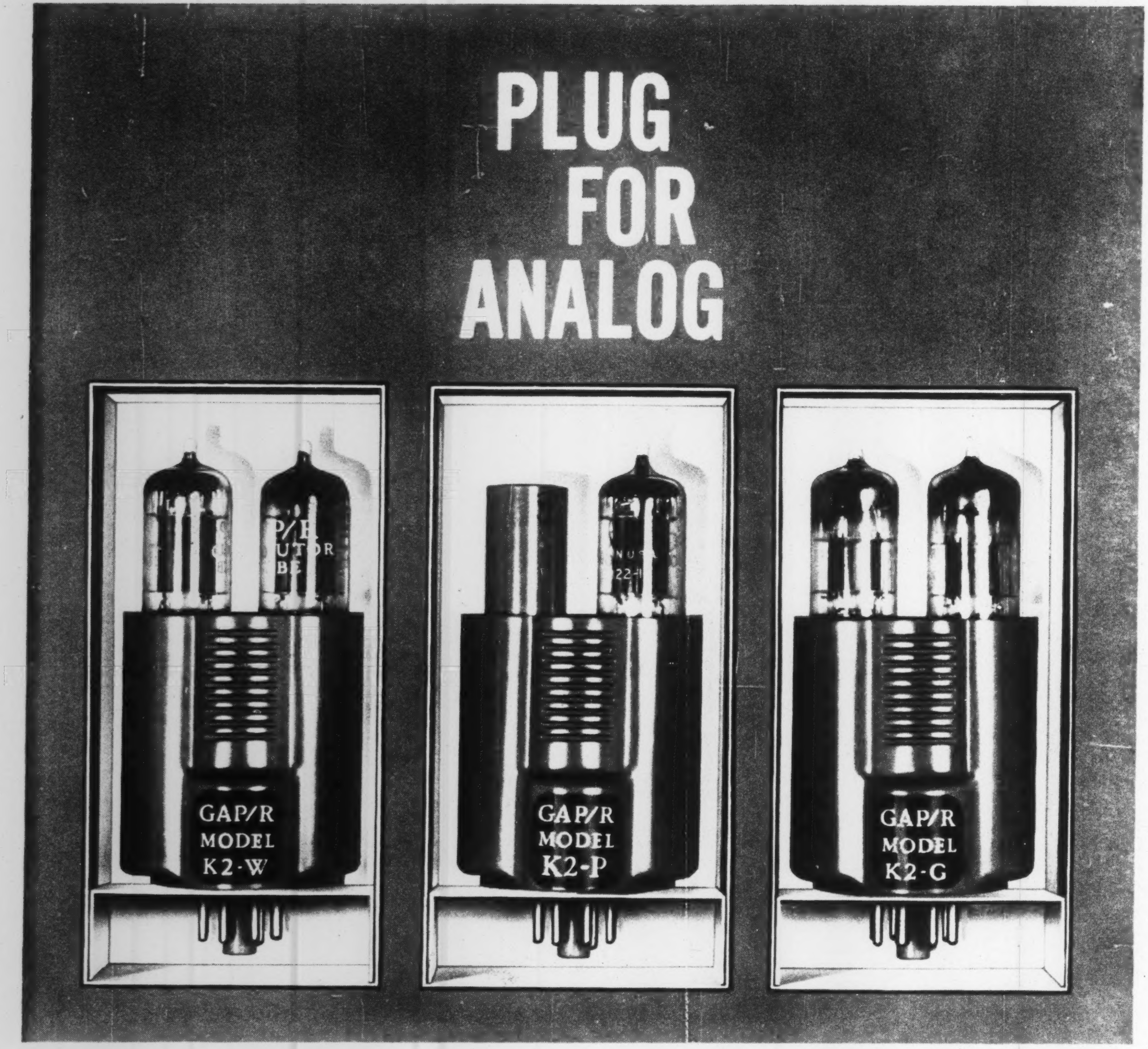

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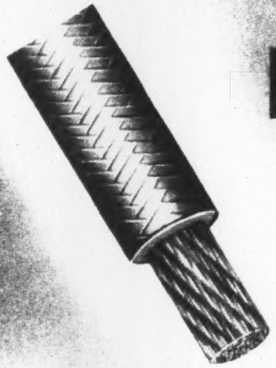

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18	8	0
16	6	00
14	4	000
12	2	0000

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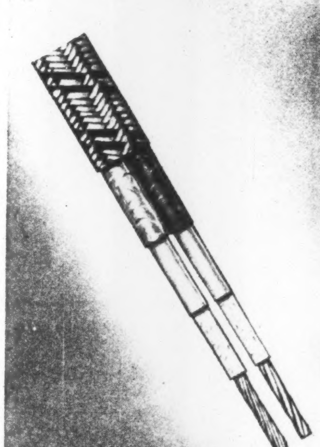

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THE LEWIS ENGINEERING CO.

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For more information circle **2** on inquiry card.

THIS MAY SEEM LIKE A LOT OF SCALES FOR *ONE* INSTRUMENT

INCREMETER
SENSITIVE RESEARCH INSTRUMENT CORPORATION
0
10
20
30
40
50
60
70
80
90
100
Model INCRE

But-

THAT'S WHAT YOU GET In the *NEW* SENSITIVE RESEARCH

INCREMETER*

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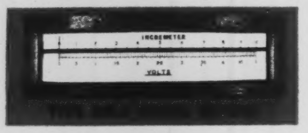
The Model INCRE essentially consists of a differential instrument of "high comparison accuracy" and a stable "high accuracy" reference source. The instrument's actual scale length is 6.3", but this represents only 10% of its total effective scale length. Each 10% of its full scale range is selected by an incremental switch thereby creating a 90% scale suppression at all times. ***Ranges*** — single or multirange from 200 mv. full scale (lowest reading .2 mv.) and 200 microamperes full scale (lowest reading .2 microamperes). ***Resolution*** — effectively 1,000 scale divisions over a 63" scale length. Each scale division has a value of .1%. ***Availability*** — portable or as a rack-mounted edgewise panel instrument. **The SRIC Differential "63" Incremeter** is a high resolution, *phenomenally* accurate measuring device with proven stability because it *is* an Electrical Indicating Instrument.



Diamond Pivoted of course!

Write for additional information on the *NEW "INCREMETER."*

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Symbol of Quality

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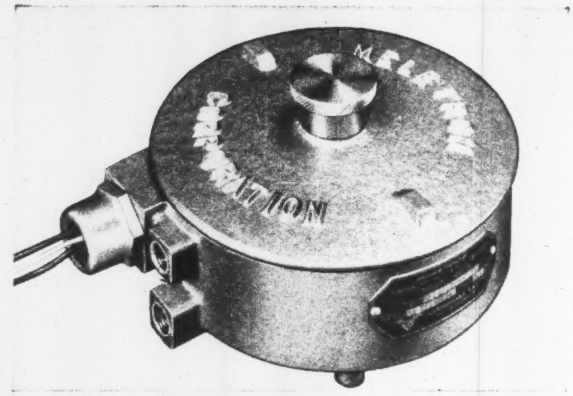
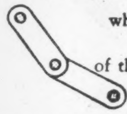
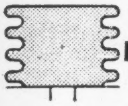


MELETRON

DIFFERENTIAL SWITCH

senses pressure differences from .45 to 45 inches of water

Used in hopper level indicating, on oil burner blower safety control, in instrumentation or similar applications where it is necessary to sense a pressure difference of .45 to 45 inches of water between a variable and a reference pressure. The reference pressure may be as high as 30 P.S.I.

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	**LINKAGES & BEARINGS**  which as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements.	**LIQUID SWITCHING ELEMENTS** which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	**ACCORDION DIAPHRAGMS**  which make the pressure switch sensitive to vibration.

To get complete specifications and operating data ask for bulletin 227 and 2273.

PRESSURE SWITCH DIVISION

barksdale valves

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INSTRUMENTS AND AUTOMATION

DECEMBER 1958

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NO. 12

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Instrumentation 1958
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Bulk Material Programming, 1985
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CHARLES F. KEZER and MILTON H. ARONSON—two more basic circuits

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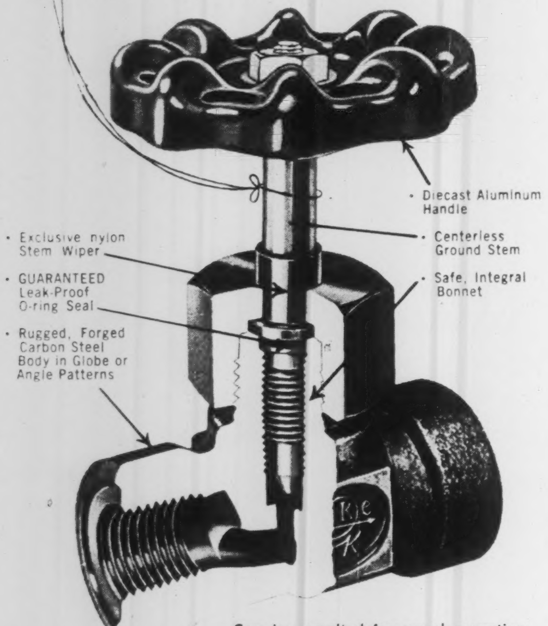
THE MAGAZINE OF INSTRUMENTATION AND AUTOMATIC CONTROL SINCE JANUARY 1928

THE INSIDE STORY*

*ON HOKE'S VERSATILE, NEW GENERAL PURPOSE VALVE



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Use these versatile, full-flow Series 100 valves for throttling, regulating, or shut-off. Use them for applications where temperatures range as low as -40° or as high as 200° F. They're compact in size and available in a selection of male and female connections. *Guaranteed* against stem leakage!

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Fluid Control Specialists
31 PIERMONT ROAD, CRESSKILL, N. J.

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INSTRUMENTS
and
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VOL. 31, NO. 12 • DECEMBER, 1958

Continued from page 1905

The Journal of
THE SOUTHERN CALIFORNIA METER ASSOCIATION

Huntington Beach Steam Station. 1988

A. L. GUIDERO—this new station represents several "firsts" for the Southern California Edison Company

THE SIMULATION COUNCIL NEWSLETTER

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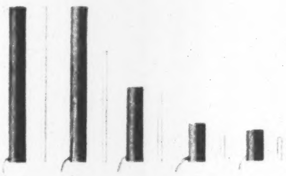
SANBORN *Transducers*

FOR LINEAR MEASUREMENTS . . .



DISPLACEMENT

LINEARSYN Differential Transformers

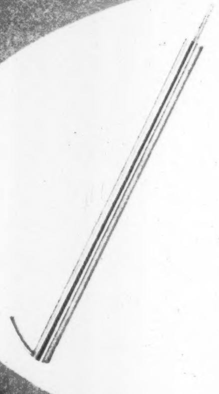
Six series of Sanborn Linearsyns — three of the shielded type, three unshielded — are available, with five models in each series. Linearity is better than 1% of full scale output in all models. Temperature range is from −50° to 205°F.

Special design features include coil assemblies hermetically sealed in epoxy, laminated phenolic jackets (unshielded types) or heavy plated steel jackets (shielded types), improved lead wire strain relief, high permeability alloy cores. Models with axial leads are also available on special order. Within each series all models have identical diameters, tap sizes, lead wires; only the lengths of coil assemblies and cores vary.

Typical Linearsyn Characteristics

Series* Unshielded	Series* Shielded	Strokes* (± inches)	Freq. Ranges	Sensitivities* (Volts/inch per volt of excitation at std. carrier freq.)
575DT	585DT	050 - 1.00	400 cps - 10 kc	56 - 3.70
576DT	586DT	050 - 1.00	60 cps - 400 cps	70 - .90
590DT	595DT	005 - 100	400 cps - 20 kc	1.60 - 2.60

*Maximum and minimum values available within each series, data on individual models on request.



VELOCITY

LVsyn Velocity Transducers

LVsyn pickups may be used to measure *linear velocity* directly, *displacement* with a simple integrating circuit, or *acceleration* with a differentiating circuit. There are twenty-four models, all self-generating with shielded cylindrical coil assemblies and high coercive force permanent magnets. Twelve models use regular magnet cores; twelve have *non-breakable* magnet cores. Characteristics of the two groups are the same except for output sensitivity, core length and weight. Features include high sensitivity, single-ended or push-pull output, accurate and stable calibration, unlimited resolution, wide range of sensitivities and sizes, temperature range of −50° to 200°F. They can be immersed in hydraulic fluid. No mechanical connection between coil and core permits low friction level. End stops or displacement limits not needed; undamaged if limits are extended.

Typical LVsyn Characteristics

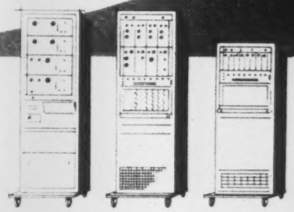
Model	Displacement: Nominal Working Range (inches)	Displacement: Maximum Usable Stroke (inches)	Electrical Characteristics: Voltage Output mv/inch	Electrical Characteristics: Total Impedance Series Connection R ohms	Electrical Characteristics: Total Impedance Series Connection L henrys
3LVA5*	0.50	1.30	120	2,000	0.085
6LV2*	2.0	3.4	500	19,000	2.4
6LV2 N	2.0	3.4	250	19,000	2.4
7LV9*	9.0	11.0	350	17,000	2.8

*Four of the twenty four models available, selected to show minimum, approximate mid range and maximum working ranges as well as the difference in sensitivity between a regular magnet core model (6LV2) and a non breakable magnet core model (6LV2 N).

NEW!

COMPLETE DISPLACEMENT TRANSDUCER

"Probe" style, uses differential transformer. With cable and adapter for connection to Sanborn 150, 350 Series Carrier Amplifiers. Stroke ± 0.070", high sensitivity, linearity 0.5%, infinite resolution, contact pressure as low as 10 grams. Stainless steel body, carbide tipped contact rod, jeweled bearings. Two models: 580—plug-in cable, flange mounting; 581—miniature, integral cable.



for MULTI-CHANNEL RECORDING

Sanborn direct writing systems now include 1- to 8-channel "150" Series, with a choice of 12 plug-in Preamplifiers; new single-cabinet, compact 6- and 8-channel "350" and "850" Series with interchangeable Preamplifiers, flush-front recorder with electrical pushbutton chart speed control and transistorized Power Amplifiers, and numerous features for high reliability and operating convenience.

For complete facts, call your local Sanborn Industrial Sales-Engineering Representative or write the Industrial Division in Waltham.

(All data subject to change without notice)

SANBORN COMPANY

Industrial Division
175 Wyman Street, Waltham 54, Mass.

For more information circle 6 on inquiry card.

Magnet Calibration

MODEL 1295
DIRECT READING
Gaussmeter
measures
magnetic flux
density
ACCURATELY

This stable, all transistorized Gaussmeter operates on the Hall effect and provides a conservative accuracy of ±3% over nine full-scale ranges: 0-100, 200, 500, 1 K, 2 K, 5 K, 10 K, 20 K and 20 K + gausses, using a single probe. Two standard Alnico V reference magnets having ¾% accuracy are supplied. Unit is housed in an aluminum case, weighs 12 lbs. and operates from 115-volt, 50-400 cps line. Price $420.

MODEL 889A

Magnetreater®

Model 889A de-magnetizes saturated magnets to any desired level of flux. Provides a precisely controlled method for rapidly treating permanent magnets, including the new core-type instrument mechanisms. Used with Model 206A Booster Unit or Model 107A Magnet Charger. Over-all size is 8" x 10" x 7". Weight 24 lbs. Price $163.

STANDARD MAGNETS

Standard Magnets

Laboratory standard fixed gap reference magnets having flux densities from 100 to as high as 20,000 gausses are now available. These units are fully stabilized magnetically, mechanically and thermally and are used to calibrate fluxmeters and gaussmeters for engineering or production testing. Certification supplied for each magnet.

Performance of all models is rigidly guaranteed. Prices are net f.o.b. Boonton, N.J. and subject to change without notice.

WE CAN HELP YOU

13 years' magnet charging experience is yours for the asking—send for illustrated data sheets.

RFL *Radio Frequency*
LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

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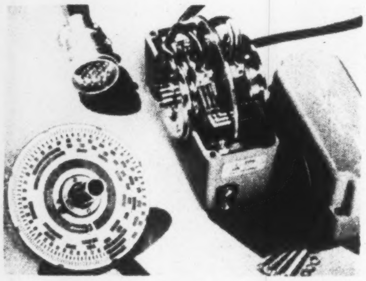
to the editor

Editor, I&A:

Your November issue on Math Tools covered many simple and basic devices and performed a needed service. One more should have been mentioned, however. The Shaft Position Encoder shown here is also a basic and simple math tool because the code can convert any dial position (which may be a number or a position of a shaft) into a sine, a cosine, a log of a cosine, etc.



One application of the Datex Shaft Position Encoder is in the generation of mathematical functions for use in special-purpose analog or digital computers. For example, a radar measures the position of a target in terms of elevation, azimuth, and slant range. To compute the height of the target it is necessary to multiply the slant range by the cosine of the elevation angle. An encoder attached to the elevation shaft of the antenna can produce a number indicating the cosine of the angle or the log of the cosine of the angle. An encoder attached to the range shaft can generate a number indicating range or the log of the range.

If a digital multiplier is available the numbers representing the cosine and the range may be multiplied. If the computer is not available the log of the cosine or elevation angle can be added automatically on a simple business type adding machine and a third encoder can be used to generate the number whose logarithm is equal to the sum computed by the adding machine. The shaft position of the third encoder will indicate the height of the target.

In a simple application, an encoder can be substituted as a simple look-up table as an aid in mathematic computation. For example, the operator may choose a dial by hand, indicating some known value. The encoder will operate a light bank which can indicate the sine, cosine, or some trigonometric function of the dial setting or can indicate the logarithm of the number set in on the dial or may be completely arbitrary as, for example, the relationship between the moisture content of coal supplied to a furnace and the optimum operating point of the furnace.

Carl P. Spaulding, Pres
Datex Corp.
Monrovia, Calif.

This does indeed qualify the Encoder as a "Basic Math Tool."

Editor, I&A:

This acknowledges receipt of the book *Digital Techniques for Computation and Control*. The volume promises some interesting reading for days to come! The presence of Mr. Aronson's name among the authors interests me as I have found other of his works most useful sources of information and reference.

Allow me also to express continued satisfaction with my monthly copy of *Instruments and Automation*. I frequently find it of real value.

Raymond Branton
Calgary, Alberta

Editor, I&A:

Referring to the article "Derivative via Integration" in the September 1958 issue, is there an error in the diagram? The circuit as shown has positive feed-back and it appears that a sign changer (inverter) is needed in the feedback path of the high gain amplifier as shown.

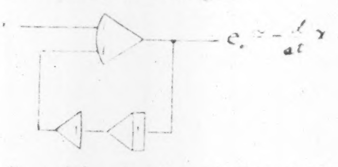
James VanArtsdalen
Boeing Airplane Co.
Wichita, Kansas

There is (see page 1753 of November issue and letter below). You analog men are on your toes!

Editor, I&A:

Regarding the article by Mr. Max Fogiel on "Analog Differentiation by Use of an Integrator", page 1525, *Instruments and Automation* for September, 1958:

The circuit shown is not practical because it is regenerative. In actual use it is necessary to interpose a sign changer (gain of —1 amplifier) between the integrator and the high-gain amplifier input. The proper circuit is shown in the figure:



A useful extension of this circuit occurs if the feedback gain is other than unity. The following analysis

RAMBLINGS ON INSTRUMENTATION

The Mysterious East

(It's-a-Small-World Division)

(Mr. Sprague and beard have recently returned from a visit to the U.S.S.R. with the Automatic Control Delegation. Herewith, some ramblings from the borscht circuit.)

Subway reading, Moscow style.

The other day, when a group of us were on the way to the Hotel Ukraine via the Moscow subway, we ran into a serious type pouring over a volume 'midst the swaying bodies. Intrigued by his concentration, we asked through our interpreter, what he was reading. The reply: a book on Automatic Control and Cybernetics. Knowing that no one would believe us, we snapped the above photo.

Seriously, this incident symbolizes the intentness with which the Soviet appears to be focusing on the theory and application of instrumentation and control devices. It was my impression that their technology is moving rapidly and is not a "house of cards"; rather it is soundly based on rigorous training in theory and application, as well as continuing emphasis on the fundamental standards which are the cornerstone of all science.

While ours was but a fleeting (and Soviet-selected) glance at an enormous country, I got the impression that—borrowing heavily from German and American designs—the Russians have built an instrument and control industry which, with a few old Lend Lease exceptions, is supplying their plant requirements.

It would appear that the focus will continue to be on producing relatively standard instruments in large quantities to meet the tremendous demand created by their 5-year plans for rapid industrialization of the country. We were told that they anticipate the instrument and control industry to increase 2.8 times between 1956 and 1960.

But we got more than a hint of their relatively new interest in foreign markets. China, Czechoslovakia, India, Argentina and 26 other countries were mentioned. Using their hole cards of, (a) concentrating large volume production of a single item in a single plant and, therefore, achieving rapidly decreasing costs and, (b) arbitrary manipulation of their exchange rates, the U.S.S.R. can be expected to be a rugged competitor on the international automation scene very soon.

Should we shudder? *No*, but I do think we should supplement the drive or motivation (which has become rather jaded of late) toward conspicuous consumption of washers, dryers, TV sets, et al, with a more individual concern for the care and feeding of our human resources. Let's face it—this is a Brains Battle and we can work out solutions for the development—*our way*—of our people of talent only if we realize it is necessary.

And, on the international competition issue, let's do more of what comes naturally; i.e. continually obsoleting products by innovation and improvement . . . constantly posing "this model is better" choices for customers here and abroad, as (commercial plug) we are trying to do here at Hays with, for example, *this year's* new products: the Universal Recorder, the new 245 flow transmitter, the 913 BTU Recorder and a new approach to gas sampling systems. So let's over-estimate the competition and rediscover our greatness.

Phil Sprague Jr.
President

THE HAYS CORPORATION • MICHIGAN CITY 8, INDIANA

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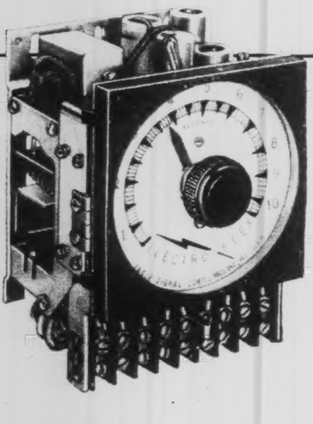
NEW EAGLE ELECTRONIC RESET TIMER SPANS RANGE FROM .1 TO 10 SECONDS

. . . COMPENSATED CIRCUIT MAINTAINS HIGH ACCURACY



ELECTROFLEX

Eagle's new Reset Timer employs only two moving parts (relay armatures), achieving precise short-interval timing through a dual range electronic circuit. Timing accuracy is maintained within 2% through line voltage variations from 90 to 130v. ambient temperature changes of 52°F. to 140°F., electronic tube replacements, and vibration up to 3g.

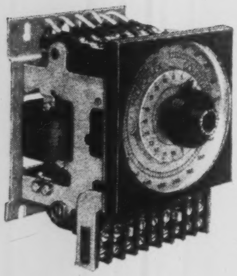
SUGGESTS NEW CONTROL IDEAS

Electroflex Dial, with precision wound potentiometer, may be mounted at the push button station with the mechanism located at a spot more convenient to wiring, installation.

PULSER

Pulsing with adjustable dwell is easily effected. Periodic output pulses may be continuously repeated with the OFF period adjustable on the dial. Pulse length (or reset time) is .050 seconds. OFF time is adjustable to 10 seconds.

COMPANION EQUIPMENT



The Electroflex Timer, the Eagle Microflex Timer, synchronous motor driven for longer time intervals, and the Microflex Counter, (shown) all share the same large 4" dial, mounting dimensions, accessories and selection of enclosures to provide uniform appearance, simplify installations.

Send for new Eagle Bulletin 150. Simply write to Eagle Signal Corporation, Industrial Timers Division, Moline, Illinois, Dept. IA 1258.

For more information circle 9 on inquiry card.

LETTERS—CONTINUED

then applies:

Let the non-feedback amplifier gain be: A.

Let the over-all feedback gain be B, where (0 < B < < ∞). Then, using the derivative operator "P", we obtain:

$$e_o = Ax - ABe_o P$$
$$e_o[1 + ABP] = Ax$$
$$e_o = Px/[B + P/A]$$

Allowing "A" to increase without limit, we obtain the limit of e_o as A approaches infinity:

$$\lim_{A\to\infty} e_o = \left(\frac{1}{B}\right)Px.$$

which is the desired relationship.

This circuit has been tried and is everything which Mr. Fogiel has claimed.

D. W. Crockett
Computer Operations Group
Box 50-85
Boeing Airplane Co.
Seattle, Wash.

Editor, I&A:

Thank you for the *Handbook of Measurement and Control. This* handbook has a wealth of common sense information that is not being fully used in the aircraft and missile industries.

I intend to make maximum use of it in my committee work.

L. A. Holcomb, Chairman
SCMA Instrumentation Committee
Convair
Pomona, Calif.

Editor, I&A:

I must express my regrets at the passing of your associate, Major Behar. I did not always agree with his ideas, but I always admired him as an authentic character one of those who make the instrumentation (this word) industry so much fun.

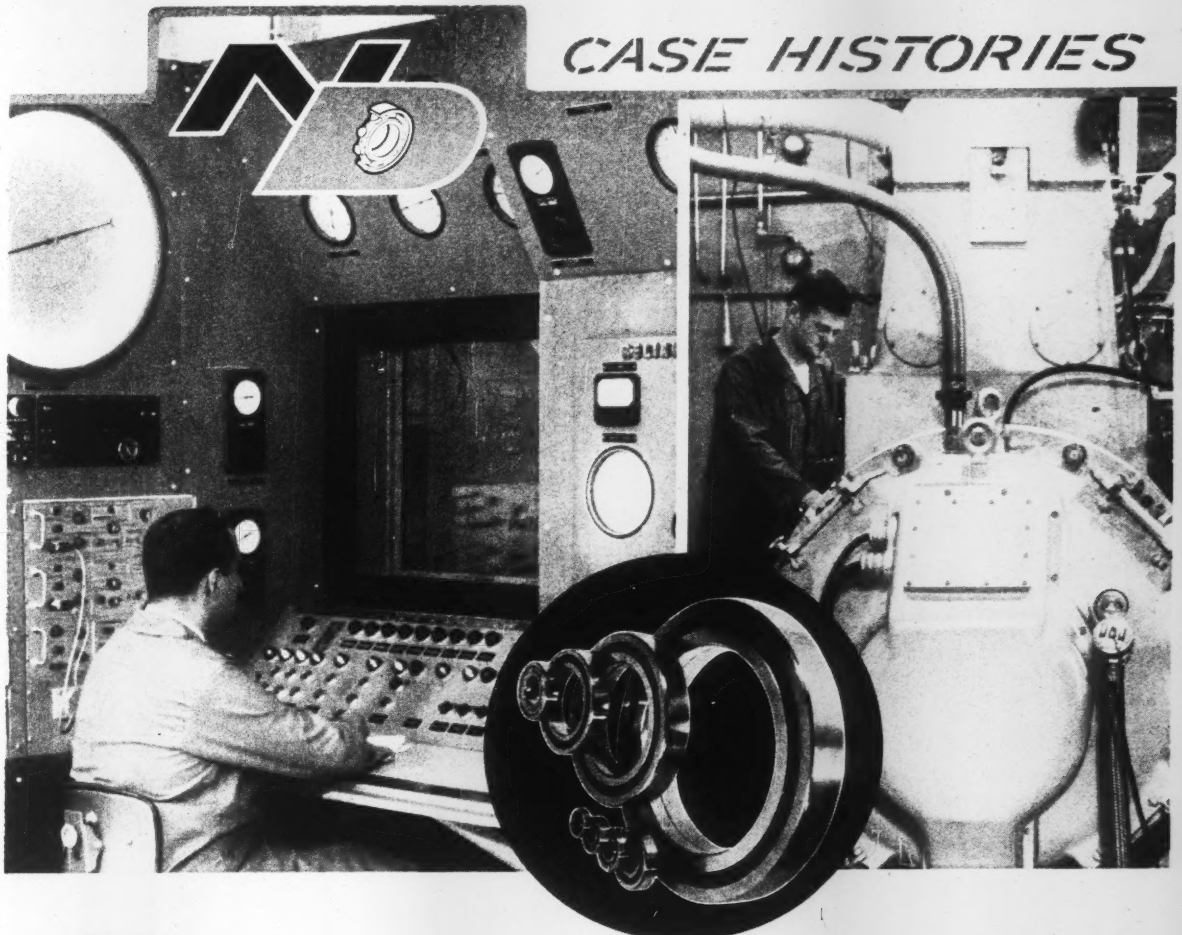
Karl W. Peterson
Trumbull, Conn.

Major Behar would have been thrilled to hear this acknowledgement of his invention of the word "instrumentation." It was one of his proudest achievements.

Editor, I&A:

I thought you might be interested to know of the reaction to my soldering article in the July issue of *I&A*. Attached is a letter requesting twelve copies of the article. Many others

CASE HISTORIES



Research Labs Keep Pace With Giant Stride Of America's Air Industry!

CUSTOMER PROBLEM:

Require test rig for measuring full scale aircraft turbine bearings. Test rig must simulate actual operating conditions.

SOLUTION:

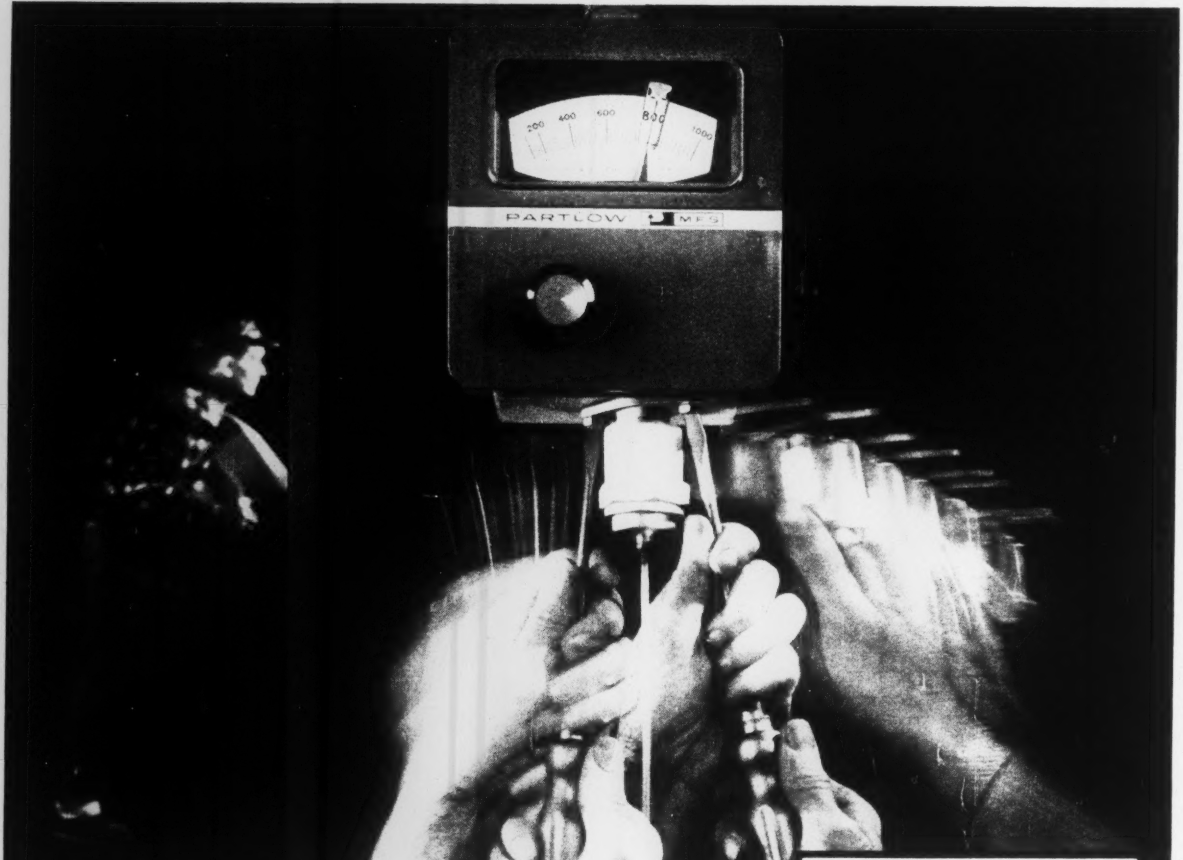
N D engineering, in cooperation with customer under the direction of a defense agency, developed the aircraft turbine bearing testing equipment shown above. The Test Rig Control Console, shown on the left, initiates and controls tests, and completely records *all* operating performance characteristics. The test stand itself, above right, simulates the actual conditions to which the bearings are subjected in flight. It develops radial loads of up to 25,000 lbs. . . . and thrust loads reaching a maximum 75,000 lbs. Bearings up to 110mm bore are tested at speeds as high as 20,000 r.p.m., in temperatures ranging up to 1200° F. Research facilities such as this are your assurance that New Departure stands ready to work closely with you on *your* bearing research problems. For information on New Departure precision Aircraft and Instrument ball bearings, or research facilities, call the New Departure Sales Engineer in your area or write Dept. I-12.

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

For more information circle **10** on inquiry card.



The Temperature Control Designed for Fast

"DO IT YOURSELF" MAINTENANCE

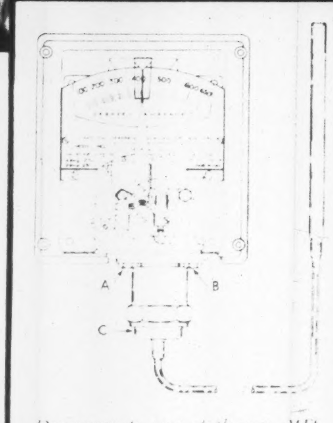
Right on the Job!

Rugged simplicity of design—along with the direct, positive power of mercury-actuation—combine to give Partlow maintenance and performance advantages no other type of temperature control can hope to equal.

Simplicity in the Partlow, for one thing, means that the control element can be changed *at the job site* in a matter of minutes with no other tool than a screwdriver . . . "Down time" is cut to an absolute minimum!

And simplicity in the Partlow also means the complete elimination of fussy electronic gadgets, delicate levers, hairsprings and other accessories that have a tendency to break down at the first trace of jar or jostle. Partlow controls are famous for their unfailingly accurate performance even under the most adverse operating conditions.

If you use or manufacture process equipment within the 30° to 1100° F. range, there's a Partlow pneumatic, electric or self-contained gas control (recording, indicating or non-indicating), to fit your application *precisely*. For details, write The Partlow Corp., New Hartford, New York. Dept. IA-1258.



Diagrammatic view of the new MFS reveals "quick-change" feature common to all Partlow controls. In case of damage, merely unscrew at points (A) and (B), and remote element (C) from case. Reverse this process, and your Partlow is ready to resume operation.

You can pay more but you can't buy better than

PARTLOW

TEMPERATURE CONTROLS

For more information circle 11 on inquiry card.

LETTERS—CONTINUED

wrote to me for reprints. Additionally, the EIA has requested that I present a paper at the December symposium on soldered connection reliability. This was also a direct result of the article, which was referenced in the request. Local engineering firms have also contacted me for additional information. This confirms my opinion that *I&A* is tops in reader coverage.

Alvin B. Kaufman
Los Angeles, Calif.

Editor, I&A:

May I extend to you my sincere thanks for your cooperation and help in locating for me a manufacturer of a latching type solenoid valve. Through the response to the article in your publication I have succeeded in locating a manufacturer of this unusual type of valve.

Our staff continues to find *Instruments and Automation* an enlightening and useful publication.

John T. Walser
North American
Weather Consultants
Goleta, Calif.

Reader Inquiries

Pressure Scanner

Swedish importer of instruments requests bids on pressure scanners. A-352

CO_2 Controller

Engineer in Argentine Department of Industry wishes to receive bids on "transducers capable of converting CO_2 percent into pneumatic 3-15 psi signals." A-353

Chromel/Alumel Thermocouples

Engineer in Portugal wishes to learn the exact composition of Chromel and Alumel as used in standard thermocouples. A-354

Barometric Pickup Humidity Indicator

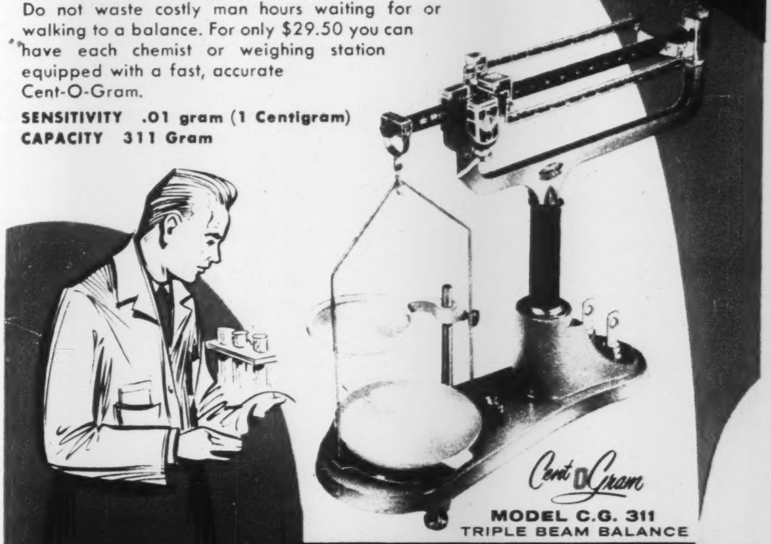
College Department Head seeks information on a barometric pickup; also on a humidity indicator for weather prediction. A-355

Distillation Equipment

Exporter seeks Lemongrass Distillation Equipment for an approximate capacity of 50 kilograms (110 lb). A-356

Precision Micrometer

Advertising agency seeks parties interested in high-precision micrometer mechanism with an overall accuracy of five millionths of an inch. Has operating range of one or two inches and four-inch barrel. A-357



Every Chemist should have one at $29.50

Do not waste costly man hours waiting for or walking to a balance. For only $29.50 you can have each chemist or weighing station equipped with a fast, accurate Cent-O-Gram.

SENSITIVITY .01 gram (1 Centigram)
CAPACITY 311 Gram

Cent-O-Gram
MODEL C.G. 311
TRIPLE BEAM BALANCE

for complete information write for FREE bulletin........

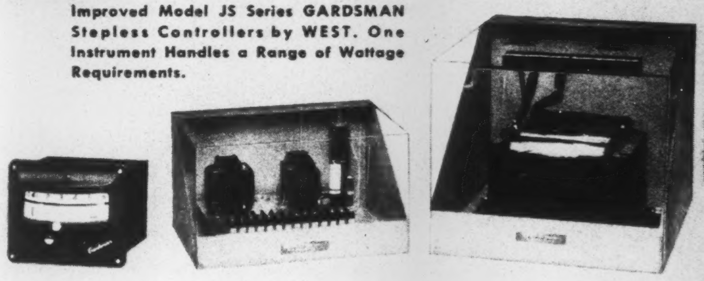
OHAUS
SCALE CORPORATION
1050 COMMERCE AVE.
UNION, NEW JERSEY

For more information circle 12 on inquiry card.

Stepless temperature Control

NOW! TUBELESS, MULTI-LOAD

Improved Model JS Series GARDSMAN Stepless Controllers by WEST. One Instrument Handles a Range of Wattage Requirements.



- ★ Closest Control
- ★ Save power
- ★ Prolong Heater Life
- ★ Adjustable Band
- ★ Manual Reset
- ★ Simplest Operation—One Knob
- ★ Least Maintenance

Without tubes or relays, this unique instrument *modulates* input to suit demand. Proved in wide use. Write for Bulletin JS.

4355 W. Montrose Ave.
Chicago 41, Illinois

WEST Instrument
CORPORATION
CHICAGO
SALES OFFICES IN PRINCIPAL CITIES

For more information circle 13 on inquiry card.

Whether you postform laminated plastic (the machine here is heating a seamless phenolic plastic counter top), or rely on temperature indicating controllers for any of a thousand other reasons, *Fenwal's 541 is the easiest to operate!*

The 541 has a host of long life features — corrosion proof 316 stainless steel, swivel mounted capillaries and bulbs . . . splash and dust proof housing. Self-compensating wear means continued accuracy with minimum maintenance. All components are accessible, easy to adjust. *It's simple and reliable!*

With ranges from −150° to +700°F., the 541 can accurately control one, two, or four circuits. Choose from several bulb and capillary styles, four basic models, variety of housing colors — hundreds of combinations to solve *your* temperature control problem. *It's versatile!*

Find out more about this Fenwal temperature indicating controller that is virtually custom-designed for you. Write to Fenwal Incorporated, 3612 Pleasant Street, Ashland, Massachusetts, and ask for a catalog or a sales engineer.

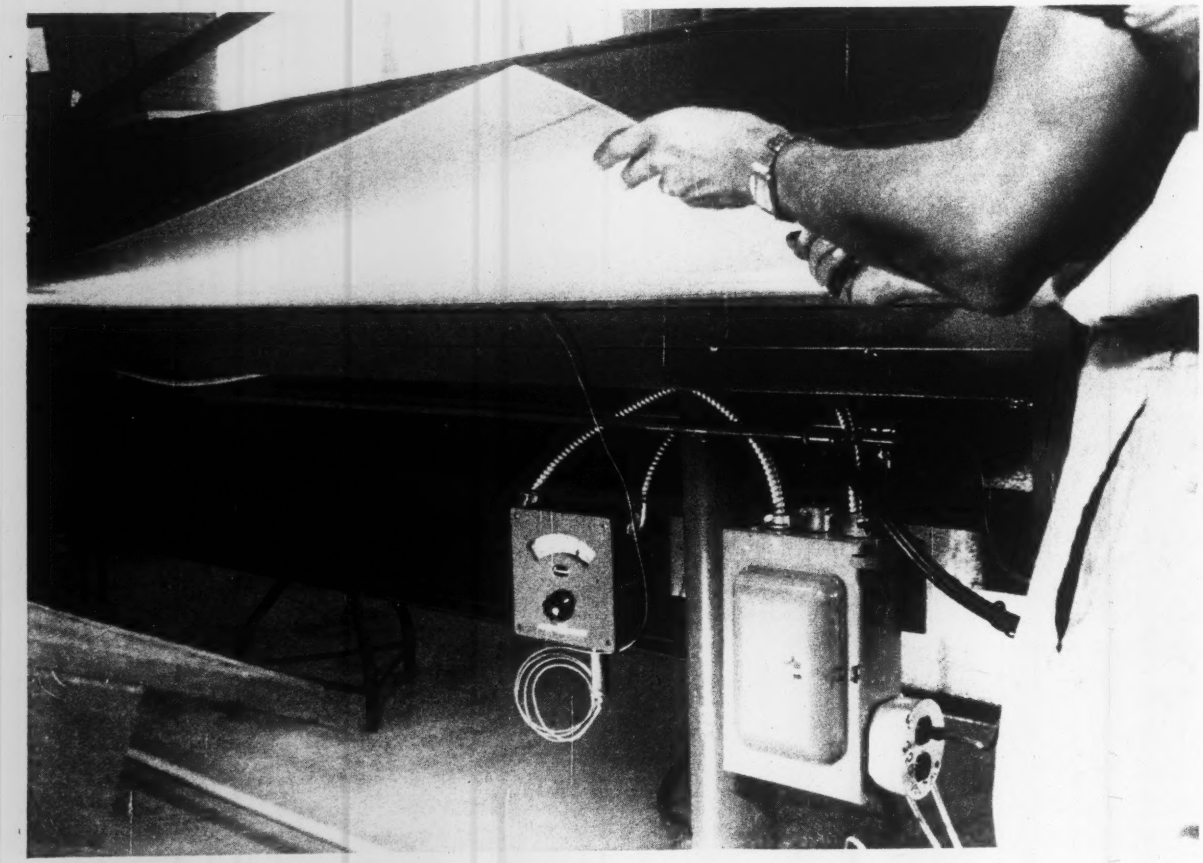
Easy does it

when you postform plastic

with the help of

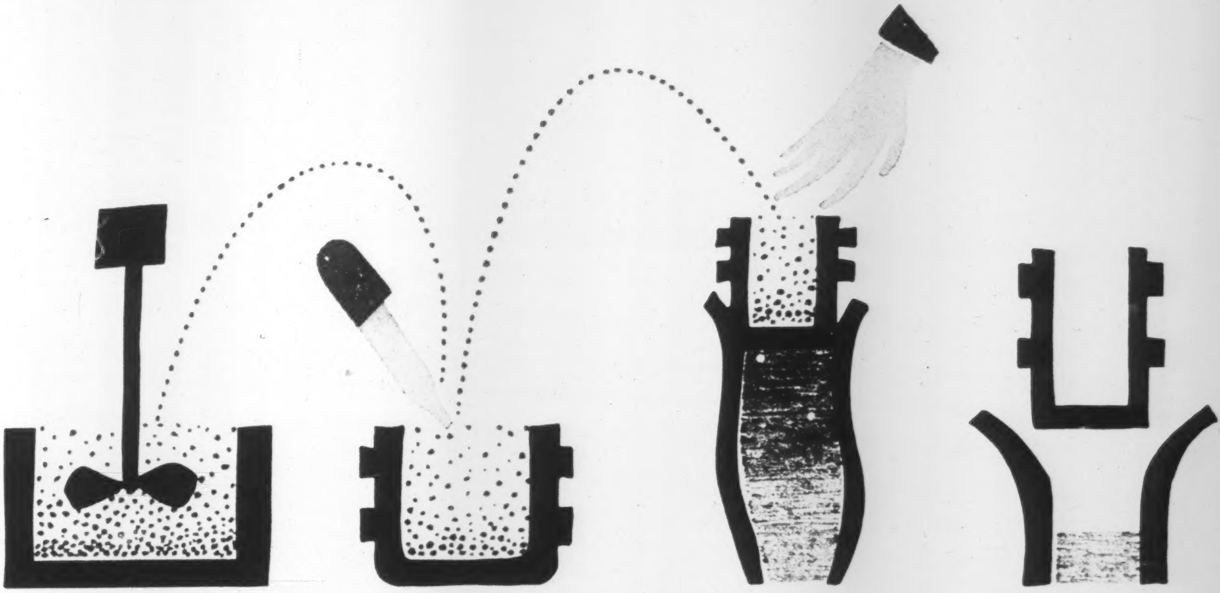
a Fenwal 541 Temperature Indicating Controller

Precise temperature controls on this press make postforming thermoset plastics easy, quick, nearly automatic. This is our single circuit model (there are 575 others) with one SPDT switch and one control pointer. Housings on all Fenwal 541's meet NEMA and JIC specifications.



Fenwal CONTROLS TEMPERATURE . . . PRECISELY

For more information circle **14** on inquiry card.

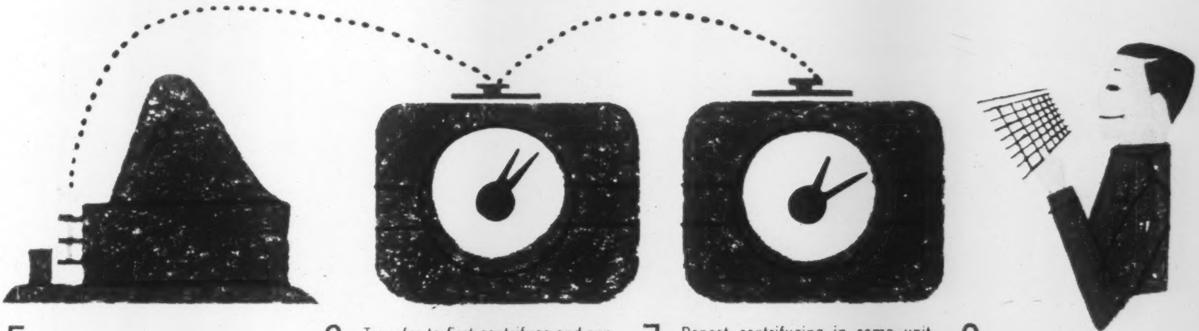


1. Prepare suspension of particles.

2. Transfer suspension to feeding chamber.

3. Transfer feeding chamber to centrifuge tube.

4. Remove feeding chamber, leaving sharp layer of suspension on top of sedimentation liquid.



5. Read sediment height under gravity in projector at precalculated times.

6. Transfer to first centrifuge and run for precalculated time, then remove and read in projector.

7. Repeat centrifuging in same unit or in higher speed centrifuges until run is complete.

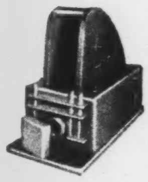
8. Size distribution is obtained from sediment height data.

New Low-Cost Way to Measure Size Distribution of Small Particles

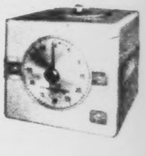
With the new M-S-A® Particle Size Analyzer, you can start with a minimum investment for measuring particle distribution, and then expand it by the purchase of additional components.

This versatile analyzer is a general-purpose device for measuring size distribution of small particles. It is especially designed for measurement of subsieve particles between approximately 0.1 and 40 microns. Most airborne dusts, paint pigments, and many flours, chemicals, and pharmaceuticals lie within this range.

Complete analyzer system includes centrifuge tubes, feeding chamber, optical tube projector, one or more special centrifuges, and tube handling and cleaning accessories. Write for new bulletin for details.



Tube Projector



Centrifuges

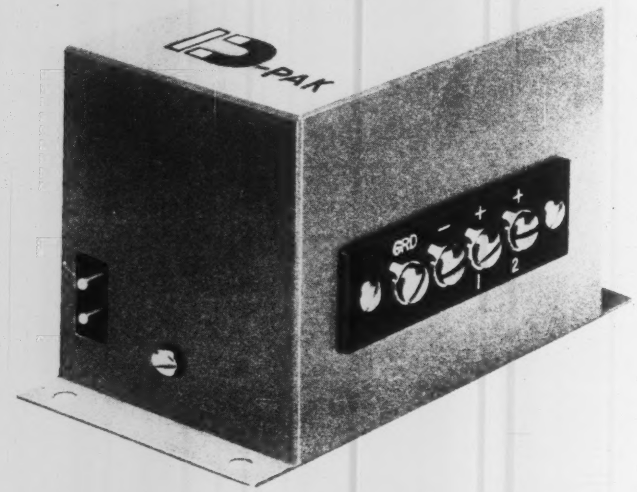
MSA

INSTRUMENT DIVISION

Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

For more information circle 15 on inquiry card.

NEW! REVOLUTIONARY! WESTON D-PAK®



SELF-CONTAINED, CONSTANT CURRENT SOURCE!

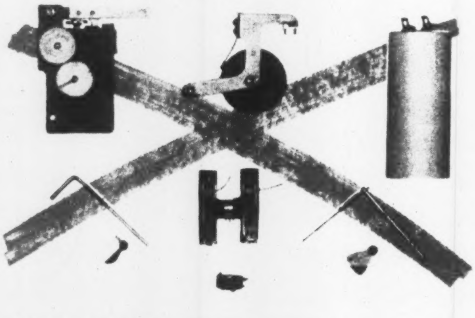
- the first high-precision constant current source for industrial potentiometers!
- eliminates many conventional components — and their maintenance!
- provides stable current supply within .05% accuracy — five times greater than the .25% accuracy of industrial potentiometers themselves!
- compensates fully for supply voltage variations down to .001% per volt!
- provides full-time accuracy; does away with interruptions in measurement for standardization!
- functions indefinitely; is not significantly affected by changes in ambient temperature!

The D-PAK makes use of refinements in semiconductor techniques which have brought under control the Zener or "avalanche" effect for voltage regulation. The circuitry is all solid state . . . there are no vacuum tubes, no moving mechanical parts. Available for use in a number of Daystrom-Weston instruments.

For further information about the D-PAK or the instrument in which it is used, contact your local Weston representative, or write to Weston Instruments, Division of Daystrom, Inc., Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 10, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.*

Replacing

batteries . . . standard cells . . .
standardizing mechanisms



DAYSTROM-WESTON

Industrial Instruments

A DAYSTROM UNIT

For more information circle **16** on inquiry card.

trends

Data storage and retrieval is growing new field. International Conference on Scientific Information (Washington, D. C., Nov. 16-21) has international significance.

British Flack Committee White Paper on evaluation of the Windscale piles, including accidental release of Wigner energy, recommends "substantial increase in the number of instruments . . . particularly for the purpose of measuring the temperature in the graphite and fuel. Apparatus for the detection of fuel element failures must be available at all times."

Transistor trends: In 1957, 40 semiconductor makers sold more than 30 million units for more than $70 million, reports M. Shepherd, Jr., of TI, who predicts that market will exceed 500 million units in 1965. Dr. Teal of TI predicts that transistor sales in 1960 will reach $250 million.

Technical house organ trend: Discontinued publication of one of nation's top house organs (GE REVIEW) shows that even large companies are watching efficiency of expenditures. Large number of technical trade publications has reduced impact of house organs, causing management to take much-needed look at (1) returns (sales leads) for advertising dollar spent, including house organ, and (2) quality of journal as established by customer surveys (not opinion of agency or company engineer).

Air passengers will number 55 million in 1960; 70 million in 1970, forecasts CAA.

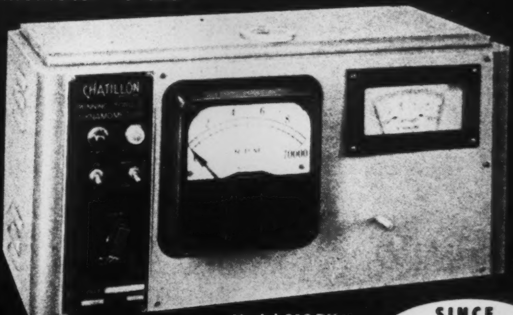
Capital outlays by manufacturer should climb from a rate of $9.5 billion in the third quarter of this year to $13.5 billion by the second quarter of 1961, predicts Fortune magazine. The energy industries—oil, gas, coal, electric utilities—should increase their spending from a low of about $11 billion last spring to $14.5 billion by the middle of 1961. Their previous peak rate was $13 billion in the third quarter of 1957. Such capital outlays would expand instrument market.

Computer installations that "fell short of hopes" are reported by J. Diebold to be 33% for large-scale computers, 44% for medium-scale computers, and 54% for small-scale computers.

The CHATILLON Running Torque Tester & Dynamometer is the

FASTEST
MOST ACCURATE
MOST ECONOMICAL way
to test fractional H.P. motors!

NOW available with a decade counter tachometer system for accuracy to ± .1% of actual speed, plus ± 1 count.



Model 210 DY

OUTSTANDING FEATURES:

- **Torque Capacities** range from .1 oz. in. to 24 lb. ft.
- **Speed Range** up to 50,000 RPM
- **Power Dissipation** varies from:
  Continuous—.013 H.P. to 4 H.P.
  ½ hour—.025 H.P. to 8 H.P.
  15 minutes—.05 H.P. to 16 H.P.
- **Tachometer Accuracy:**
  .1% of full scale with electric tachometer.
  ± .1% of actual speed plus ± 1 count with decade counter tachometer system
- **Temperature Compensated Springs**
  Made of Chatillon Iso Elastic® material
- **Automatic Overload Protection**

Special Units can be designed to meet specifications.

WRITE FOR DEMONSTRATION
WRITE FOR ILLUSTRATED BROCHURE

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CHATILLON
1835

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JOHN CHATILLON & SONS
85 CLIFF STREET, NEW YORK 38, N.Y.

Manufacturers of Scales, Force Measuring Instruments and Precision Springs Since 1835

For more information circle **131** on inquiry card.

NEW American®
GASCLOK Power Drive
constant high power • uniquely accurate

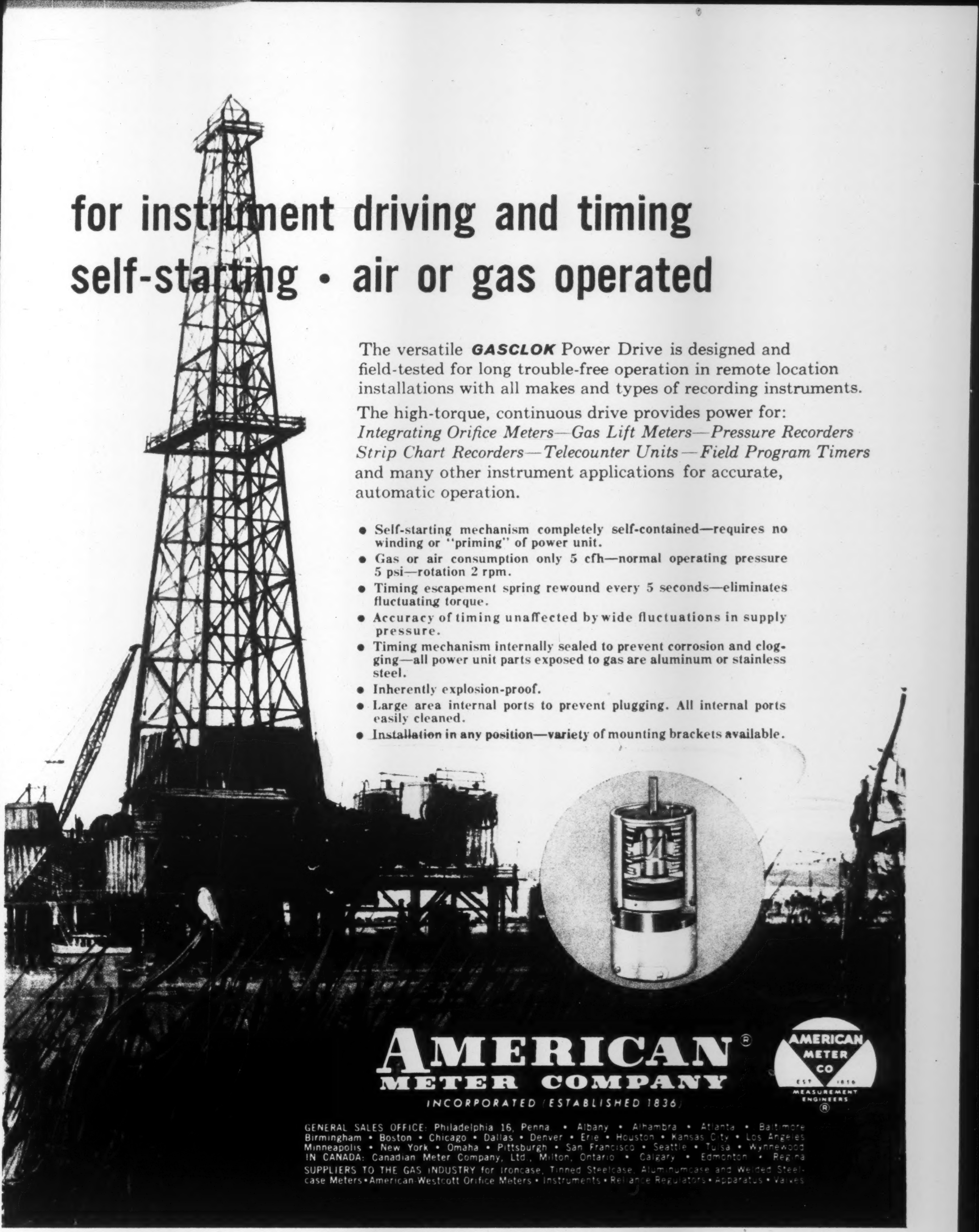
American's new ***GASCLOK*** is a completely self-contained air or gas powered instrument drive and timing unit. Supplying a constant power output of over 20 times the torque delivered by conventional spring-wound clock mechanisms, it is ideally suited as either original or replacement equipment where continuous power and accurate timing are essential.

Perfect for all circular or strip chart records from one-hour to 30-day periods. Constant power and timing accuracy are assured since there is no "mainspring" to weaken or run down. Rugged durability and dependability are built into the ***GASCLOK*** Power Drive for years of service with minimum maintenance. It can provide new metering accuracies and economies for you.

GASCLOK
SERIES NO. 50
SERIAL NO.
MODEL NO.
R.P.M.
IN. OZ.
EXHAUST
SUPPLY
AUXILIARY
±1PSI
AMERICAN METER CO.

Actual Size

For more information circle **17** on inquiry card.



for instrument driving and timing self-starting • air or gas operated

The versatile ***GASCLOK*** Power Drive is designed and field-tested for long trouble-free operation in remote location installations with all makes and types of recording instruments.

The high-torque, continuous drive provides power for: *Integrating Orifice Meters—Gas Lift Meters—Pressure Recorders Strip Chart Recorders—Telecounter Units—Field Program Timers* and many other instrument applications for accurate, automatic operation.

- **Self-starting mechanism completely self-contained—requires no winding or "priming" of power unit.**
- **Gas or air consumption only 5 cfh—normal operating pressure 5 psi—rotation 2 rpm.**
- **Timing escapement spring rewound every 5 seconds—eliminates fluctuating torque.**
- **Accuracy of timing unaffected by wide fluctuations in supply pressure.**
- **Timing mechanism internally sealed to prevent corrosion and clogging—all power unit parts exposed to gas are aluminum or stainless steel.**
- **Inherently explosion-proof.**
- **Large area internal ports to prevent plugging. All internal ports easily cleaned.**
- **Installation in any position—variety of mounting brackets available.**

AMERICAN® METER COMPANY

INCORPORATED (ESTABLISHED 1836)

AMERICAN METER CO
EST 1836
MEASUREMENT ENGINEERS ®

GENERAL SALES OFFICE: Philadelphia 16, Penna. • Albany • Alhambra • Atlanta • Baltimore Birmingham • Boston • Chicago • Dallas • Denver • Erie • Houston • Kansas City • Los Angeles Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle • Tulsa • Wynnewood
IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton • Regina

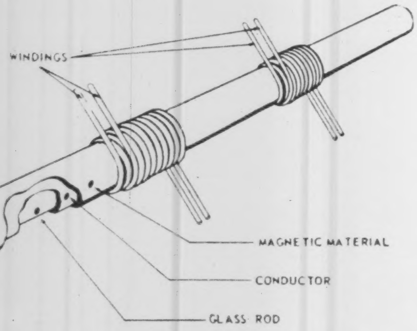
SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase and Welded Steelcase Meters • American-Westcott Orifice Meters • Instruments • Reliance Regulators • Apparatus • Valves

For more information circle **17** on inquiry card.

news

Computers will Think Faster

PHILADELPHIA. PA.—A magnetic device the size of a pin, developed by the National Cash Register Company's Electronics Division, promises to increase the "thinking" speed of future electronic computers 10 to 20 times.



The device, a glass rod, 0.015" in dia. with a magnetic coating and small windings of wire around the rod, serves as both a switching and information storage element. Top speed of the device is yet unknown. However, research models have exhibited switching speeds as fast as 4 millimicroseconds. The rod element can be used both in word-ordered and coincident-current memory circuits. Only 0.020 of a watt is required to store a "bit" of information on the rod. A rod-memory system the size of a cigarette pack could store 8000 bits of information.

Alfred A. Markson

Alfred A. Markson, assistant vice president of Hagan Chemicals and Controls, Inc., died November 23, 1958. He was 54 years old. A 1924 engineering graduate of Rensselear Polytechnic Institute, he had been with Hagan as a consulting engineer since 1942. In 1955 he was appointed assistant vice president.

Mr. Markson was the author of many technical papers, a recent one being "Introduction to Reactor Physics" in April 1958 *I&A*. He had recently specialized in studies dealing with nucleonics. Before the advent of nucleonics he had been influential in the development of steam generating equipment, having been a research engineer at Consolidated Edison Electric Co. from 1936 to 1942 and a steam station design engineer at the New York Steam Corporation from 1924 to 1936.

A registered professional engineer in Pennsylvania and New York, Mr. Markson was active in the ASME and the ISA. Al Markson's death means the loss of a fine, kind and capable gentleman to our industry and our nation.

Automatic Soap-Batching System in Synthetic Rubber Production

PHILADELPHIA. PA.—In the making of synthetic rubber at the Phillips Chemical Company copolymer plant, Borger, Texas, automatic control of the concentration of a soap solution was achieved by consistent weighing to an accuracy of ±0.10%. The system uses Baldwin-Lima-Hamilton SR-4 load cells and allied control equipment. The reaction that produces the rubber occurs in an emulsion formed by agitating the two monomers in a solution of water and soap.

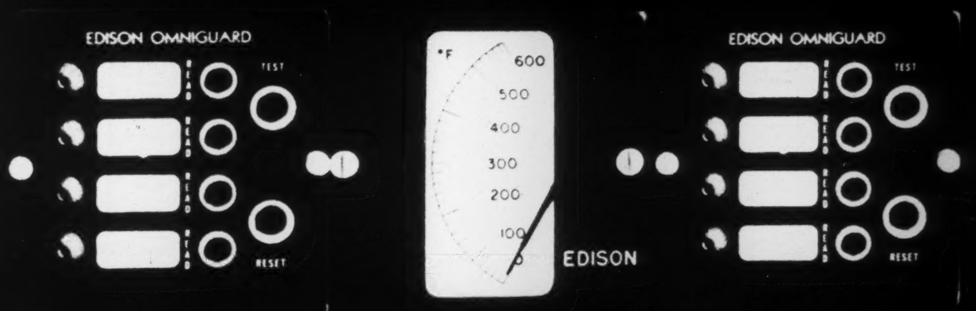
The operation of the B-L-H automatic sequence controller is composed of eleven phases. All of these phases are accomplished in a single mixing tank that is supported by four B-L-H SR-4 load cells. The operation is regulated and recorded by a B-L-H batch controller contained in a console located 50 feet from the operation. A continuous strip recorder in the console charts all weights and time periods in the process. A unique feature of the system is that the controller re-zeroes itself prior to each addition of a new ingredient.

At the end of each phase a deviation recorder tells the operator whether the ingredient added was over or under weight. The operator can correct these deviations by placing the sequence controller in manual operation and adding the necessary ingredients semi-automatically.

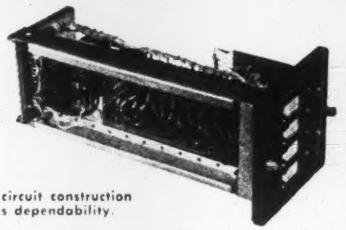
Philadelphia's Water System Gets Electronic Load-Control Center

SYRACUSE, N. Y.—Microwave engineers of the General Electric Communication Products Department are working on final plans for a unique electronic pushbutton control system for the Philadelphia Water Department.

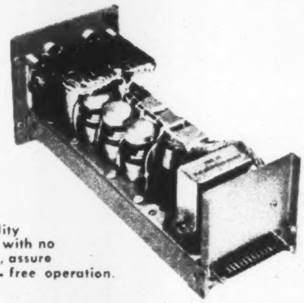
The $432,000 contract provides for eight stations which will furnish the communications link permitting the load control center to collect information from 92 points in the city where measurements are made on reservoir levels,



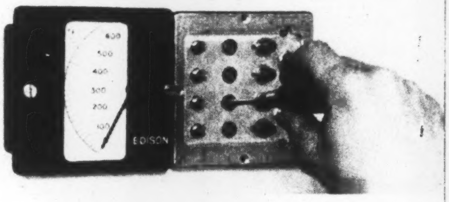
Model 310 Edison Omniguard with Model 311 Indicator — a single indicator can read any number of temperature points.



Printed circuit construction increases dependability.



Highest quality components, with no moving parts, assure maintenance-free operation.



Easy access to all components permits quick temperature settings and monitoring system changes – at any time.

THOMAS A.

EDISON

new model 310 omniguard temperature monitor... unmatched for versatility

The new Model 310 Edison Omniguard provides the simplest, most dependable temperature detection system yet devised... for both small and large installations.

The Omniguard system is reliable... flexible... economical. You order only the plug-in units needed, add new units as your monitoring needs expand.

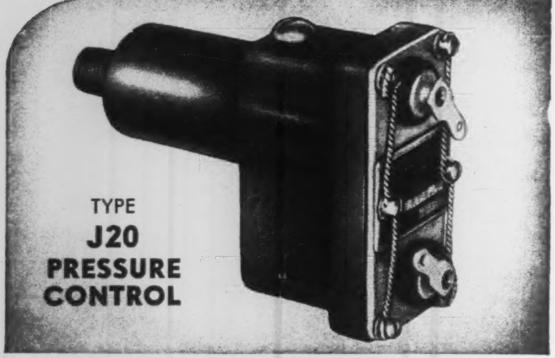
Check these features of the new Edison Omniguard:

1. **VERSATILE:** One instrument can be used for both normally open and normally closed annunciator... for alarm or for shutdown of equipment.
2. **FLEXIBLE:** Quick, inexpensive system changes and additions . . . easy tie-in with any type annunciators or cut-off switches.
3. **DEPENDABLE:** Rugged design with highest quality components, no fragile moving parts.
4. **SIMPLE:** Single indicator reads any number of temperatures, needs no periodic adjustment. With a minute's briefing, *anyone* can operate the simple Omniguard monitoring system.
5. **LOW COST:** Plug-in units can be custom-tailored to your exact requirements . . . order additional units only when needed.

Thomas A. Edison Industries
INSTRUMENT DIVISION
24 LAKESIDE AVENUE, WEST ORANGE, N. J.

EDISON FACTORY OFFICES ARE LOCATED IN: EVANSTON, ILLINOIS; DALLAS, TEXAS; DAYTON, OHIO; SHERMAN OAKS, CALIFORNIA

For more information circle **18** on inquiry card.



Proven
ABSOLUTE PRESSURE CONTROLS
J20

by UNITED ELECTRIC

The Type J20 Absolute Pressure Control with its spring loaded, completely evacuated bellows provides positive switching . . . in response to source pressure variations . . . independent of atmospheric pressures and temperatures.

Pressure Range	0 to 35 psia
Adjustable Range	5.0 psia
Adjustments	factory calibrated at mid-point of the 5.0 psia adjustable range specified
Differential	factory set anywhere within limits of 1:5 to 5.0 psia
Repeat Accuracy	0.1 psia between 65° F to 160° F, altitude to 60,000 feet, 100% relative humidity
Switch Ratings	4 amps with non-inductive load of 28 volts D.C. or 10 amps at 115 volts A.C.
Switch Types	single-pole, single-throw, snap-acting class R—NC—opens on decreasing pressures class G—NO—closes on decreasing pressures
Electrical Connections	solder terminals on face of control can be pivoted and soldered in any position
Mounting	1/8" NPT, male thread to pressure source
Weight	approx. 5 ounces
Size	3 5/32" x 2 11/32" x 1 3/32"
Applications	pressuring pumps on air-borne, mobile, or other equipment also in pressurized coaxial cables, in ground radar, and in maintaining frequency bands

UNITED ELECTRIC *also manufactures a complete line of temperature and pressure and vacuum controls . . . to exacting specifications . . . for innumerable applications. Special controls, modifications or custom-built, are available . . . consult a UE application engineer today.*

Write for J20 Bulletin today.

UE®
United Electric Controls
COMPANY
85 SCHOOL STREET, WATERTOWN, MASS

For more information circle 19 on inquiry card.

NEWS—CONTINUED

water pressure, and the flow of water through municipal lines.

Electronic pulses from each of the 92 points will be telemetered continuously and sent via microwave to the control center. There, a data logger will convert the pulses to digital information.

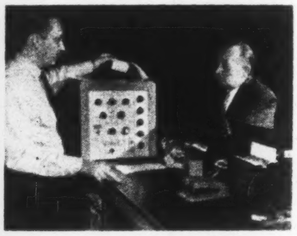
A logging printer will permit automatic transfer of coded information to a typewriter in numerical form for the department's permanent record.

The recorded digital information will give the Water Department valuable statistics for analytical purposes. With the data, the Department expects to attain greater efficiency in taking care of the city's water consumption needs.

INTERNATIONAL CORRESPONDENCE SCHOOLS have added a new text, *Components and Circuits in Electronic Data-Processing Machines* to the curriculum. Prepared by Mr. Julius Breczinski, Electronic Training Coordinator, Plymouth Div., Burroughs Corp., the new text is intended primarily for technicians now working on mechanical business machines who will switch over to electronic machines.

GENERAL ELECTRIC has installed a closed-circuit television monitor which gives the railroad crossing tender a mirror-sharp picture of switching engines approaching the main line from an industrial spur track (middle of monitor screen) a half mile away. The camera is enclosed in a bullet-proof housing, and is equipped with windshield washer, wipers and a defrosting mechanism.

GE ITV


DETECTO Computer

DETECTO SCALES has developed an automatic Baggage Computer which in six seconds records weight of airplane passenger's baggage, deducts free weight allowance, shows the amount of over-weight, and computes the charge for excess poundage according to passengers' destination.

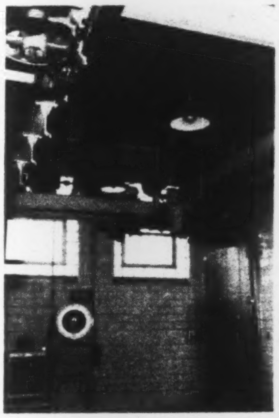
FISCHER & PORTER CO's. Digital Multiple Pressure Measurement System utilizes 800 feet of Nylaflow polyamide pressure tubing (supplied by The Polymer Corp.) with a savings of 50% in installation over copper tubing.

LEACH CORP. has built an industry-wide Production Reliability Center that will expose components and systems off the production line to stresses far beyond any they will encounter in space.

LICA, the newly formed Long Island Computer Association, held its first meeting in Garden City, October 14. Mark I, Whirlwind (with interpretative-type coding procedures for programming) and Univac were demonstrated; and the recently announced method of automatic programming, Flow-Matic, was explained.

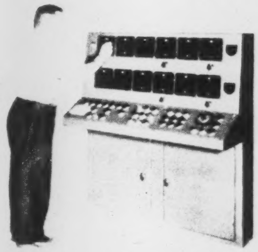
LOOK TO TOLEDO for Progress in the World of Weighing

MULTI-SCAN FOR WEIGHING ITEMS IN MOTION

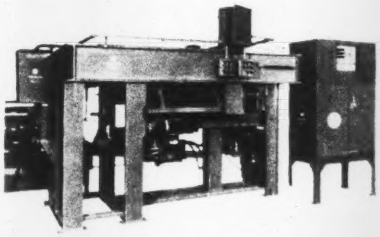


For items moving on overhead tracks (hog carcasses, for example) Toledo Multi-Scan system provides accurate average weights without necessity of bringing the swaying carcasses to rest. Weight data is fed into remotely located adding or other office machines for listing and totalizing of weights. Identifying data may also be introduced through key input stations.

AUTOMATIC BATCHING SYSTEMS



"Remocon" controls feature remote setting for fully automatic operation. Simple dial knob adjustments control quantities of each ingredient, allow precise duplication of batches. Extremely flexible — use with a single scale or multiple scale batching system.



PRODUCT TESTING AND CLASSIFYING

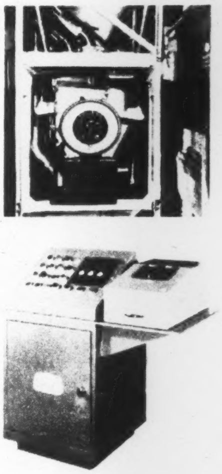
This custom-engineered Toledo automatically tests and classifies large coil springs. It is one of many types of Toledos used for classifying a wide range of items — from small packages to large cartons and production parts — in a variety of manufacturing operations.

Check These Specialized Jobs TOLEDOS Are Doing

When you have a problem in weighing, testing, counting, batching, sorting or weight data processing . . . and you want the practical, economical answer . . . it will pay you to check with Toledo. Toledo's complete line of industrial scales provides today's effective answer for a wide range of needs; or for special applications, Toledo Scale engineers will work with you on modifications or completely custom-engineered units. Toledo's huge reservoir of experience is your assurance of a practical, cost-saving solution. Let us help you. Write TOLEDO SCALE, Division of Toledo Scale Corporation, Toledo 12, Ohio.

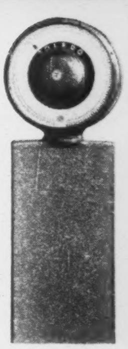
TOLEDO® HEADQUARTERS FOR WEIGHING SYSTEMS

AUTOMATIC BULK WEIGHING



Toledos provide accurate, net weight listing and totals of bulk materials going into truck or carload shipments. Weighing is automatic. A Toledo weight-control console with automatic recording and totalizing unit may be remotely located for operating convenience.

ELECTRONIC AND HYDRONIC SCALES



Toledo Electronic Scale heads may be remotely located wherever convenient, because there are no mechanical connections. Toledo offers full electronic scales, also combinations with hydraulic or mechanical components to meet a wide range of requirements. For specific applications, digital indication of parts counts may be provided electronically.

For more information circle **20** on inquiry card.

You told us to "tell all" about this ALL-NEW PANEL-MOUNTED HIGH SPEED ELECTRICAL COUNTER

You asked for it! Hundreds of requests for "complete specs" rolled in on the announcement of the 1591. So here they are . . . all on one sheet . . . for your counter file. And here's a quick review of the most newsworthy features of this all-new counter:

- Instant electric resetting.
- Push-button reset, either mechanically on the machine, or electrically from a distance.
- One button resets an entire panel.
- Panels can go right in your office.
- Counter is small, but figures are large.
- Speeds rated to 3,000 counts per minute.

ORDER NOW!

EVERYONE CAN COUNT ON

Veeder-Root

INCORPORATED

Hartford 2, Connecticut

Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago
New York • Los Angeles • San Francisco • Montreal
Offices and Agents in Principal Cities

Complete Specifications ...Series 1591 Counter

•

Overall Dimensions: 2.1″ wide, 1.7″ high, 2.6″ deep. Shipping weight approximately 1 lb.

Method of Counting: Actuated through electromagnets, these counters can be connected in series with any device having a contact arrangement. For optimum operation, 60% contact time is necessary.

Reset: Manual or electrical. Manual reset is accomplished by depressing the reset button extending through the front panel. Electrical reset is accomplished by energizing the resetting coil momentarily.

Size of Figures: .188″ high.

Color of Figures: White on black.

Number of Figures: 4 or 6.

Speed: 3000 counts per minute is the maximum recommended.

Watt Consumption: Operating coil — 6 watts, reset coil — 15 watts.

Operating Voltage: 6, 12, 24, 48 & 115 volts DC are standard. For operation on AC power, suitable electrical components must be added externally to the counter.

Reset Voltage: 6, 12, 24, 48 & 115 volts DC are standard.

Voltage Variation Permissible: 10%, but not more than 10 volts.

Temperature Rise: 140°F under normal operating conditions when coils are left energized for long periods of time.

Lubrication: After every 30-million counts, lubricate per Veeder-Root service instructions V-78116-1.

Finish: Die-cast frame, with aluminum covers. Panel Plate dull instrument black.

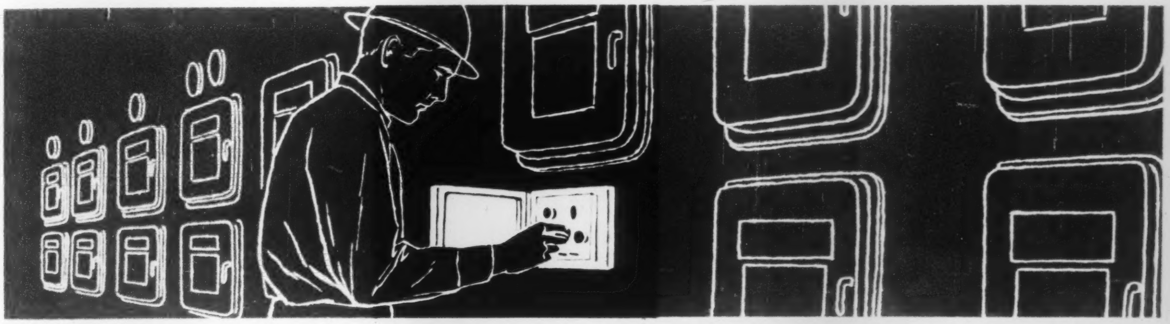
NOTE: Any change in any of these Standard Specifications (above) makes the counter a Non-Standard item, produced to order only.

For Your COUNTROL FILE

For more information circle **21** on inquiry card.

Here's the ***heart*** *of your process control center...*

CEC's process chromatograph



Put your finger on the simplest, most reliable analytical instrument in chemical and petroleum processing: CEC's 26-202 Process Chromatograph. This is the completely transistorized, trouble-free system that's improving quality control and solving processing problems throughout industry.

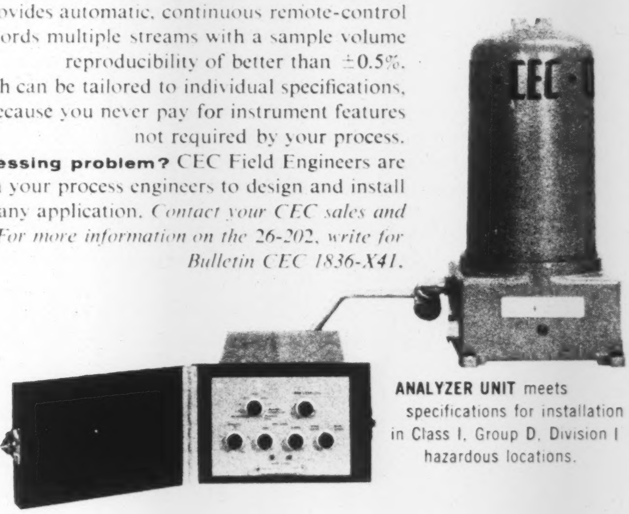
Operating personnel depend on its rapid response and precise reproducibility to take the guesswork out of process adjustments. The 26-202 provides automatic, continuous remote-control monitoring...records multiple streams with a sample volume reproducibility of better than ±0.5%.

This basic chromatograph can be tailored to individual specifications, actually costs less because you never pay for instrument features not required by your process.

What is your processing problem? CEC Field Engineers are available to work with your process engineers to design and install complete systems for any application. *Contact your CEC sales and service office today. For more information on the 26-202, write for Bulletin CEC 1836-X41.*

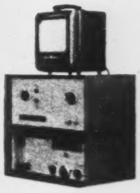
TYPICAL PROCESS APPLICATIONS

- Alkylation
- Butadiene Processing
- Natural Gas and Gasoline Production
- Annealing Furnaces
- Ammonia Synthesis
- Chlorine Production
- Flue Gas Analysis
- Catalytic Reforming
- Polymerization
- Catalytic Cracking
- Isomerization



CONTROL UNIT can be located at least 500 feet from the Analyzer Unit.

ANALYZER UNIT meets specifications for installation in Class I, Group D, Division I hazardous locations.



FOR THE LABORATORY... CEC's versatile 26-201A Laboratory Chromatograph guarantees speed and superior reproducibility. Easily operated by untrained help.

Analytical & Control Instrument Division CEC

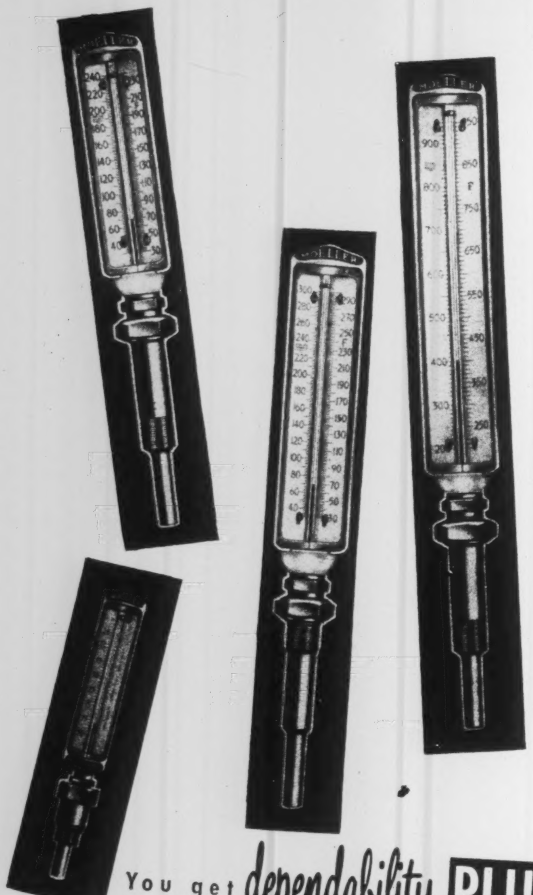
Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

FOR EMPLOYMENT OPPORTUNITIES *with this progressive company, write Director of Personnel.*

For more information circle **22** on inquiry card.



You get *dependability* **PLUS**

in Moeller Industrial Thermometers

because our business has been the design and manufacture of temperature measuring instruments since 1867.

Moeller Industrial Thermometers are made in any form—straight angle, right or left side angles, reclined or inclined angles, in scale ranges of —120°F to plus 1125°F or in centigrade equivalents. Available in 5", 7", 9" and 12" scale sizes with plain stems, union connection stems and separable sockets in all stem lengths and alloys. *Mail the coupon today for detailed information.*

MOELLER
INSTRUMENT COMPANY
132nd ST. and 89th AVE.
RICHMOND HILL 18, N. Y.
Representatives in Principal Cities

Gentlemen: Without obligation, please send me Moeller Catalog No. 150 on Industrial Thermometers.

NAME
FIRM
ADDRESS
CITY ZONE STATE

For more information circle 23 on inquiry card.

stock report

Any further information concerning any of the following issues may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

American Stock Exchange:

AMERICAN STOCK EXCHANGE
Price Range for 1958 Thru Nov. 18, 1958

	HIGH	LOW	Price as of 11/18/58
American Meter	29 1/2	[illegible]	[illegible]
Arc Equipment	21 1/2	13 3/4	22
Barry Controls B	10 7/8	4 3/8	[illegible] 7/8-10 3/8 (1)
Belock Instruments	11 3/4	[illegible] 3/8	10 3/8
Benrus Watch	[illegible]	4 7/8	6
Breeze Corp.	7 1/8	5 1/8	[illegible] 7/8
Clark Controller	24	14 3/8	19 3/4
Clarostat Mfg.	4 3/8	[illegible]	3 3/4
Clary Corp.	5	2 7/8	4 3/8
DuMont Laboratories	5 5/8	3	4 7/8
Dynamics Corp. of America	5 3/8	2 7/8	4 5/8
Electronics Corp. of America	12 7/8	6 3/8	11 3/4
El-Tronics	3 3/4	1 5/8	2 1/4
Fairchild Camera & Instrument	48	19 1/2	44 7/8
Globe-Union	20 1/4	14 5/8	19 1/4
Hazeltine Corp.	52 3/8	30 1/2	42
International Resistance	5 7/8	3 3/4	5 1/2
Lear, Inc.	8	4 1/4	7 7/8
National Research	17 3/8	12 7/8	15 1/2
Neptune Meter	31	19 1/2	29
New Haven Clock	3 1/4	7/8	1 1/8
Nuclear Corp. of America	1 1/2	7/8	1 1/8
Pneumatic Scale	36	18 1/2	31 - 33 (1)
Servo Corp.of America	15 3/8	3 3/4	14 5/8
Servomechanisms	11 1/8	6 5/8	9 3/8
Wallace & Tiernan	40 3/4	24	39 7/8
Waltham Prec. Instrument Co.	1 1/2	13/16	1

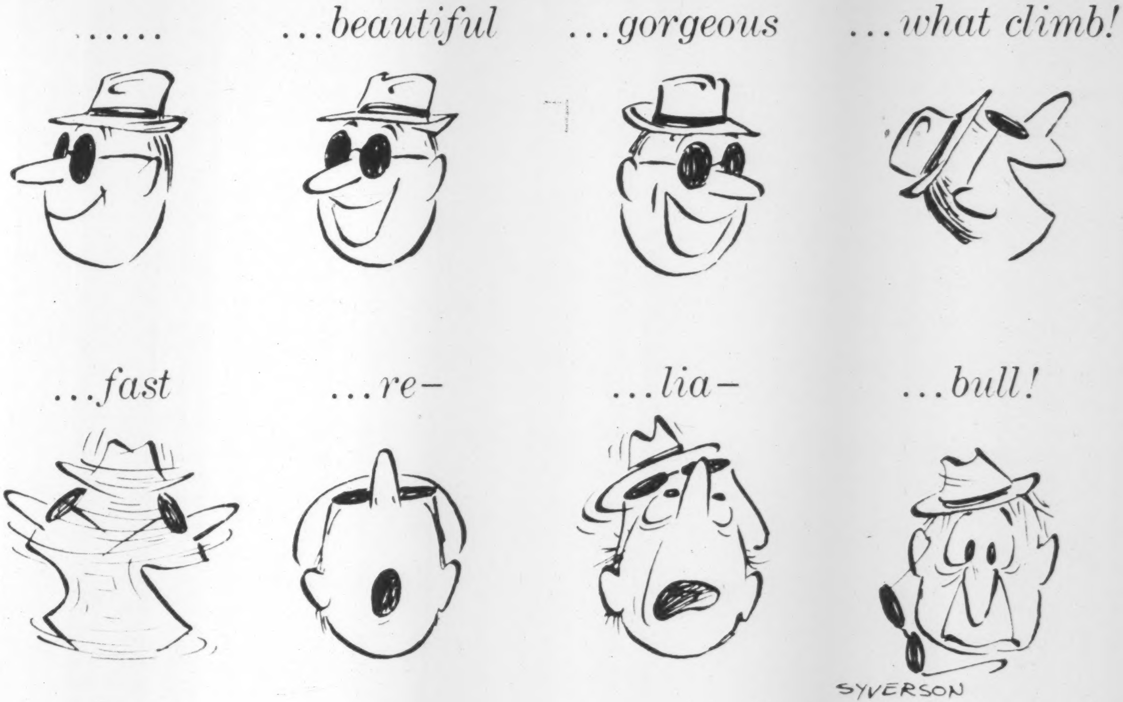
(1) Not Traded - Bid and Asked

New York Stock Exchange:

NEW YORK STOCK EXCHANGE
Price Range For 1958 Thru Nov. 18, 1958

	HIGH	LOW	Price as of 11/18/58
ACF Industries	[illegible] 5/8	[illegible] 1/8	58
Aeroquip Corp.	25 3/4	16 7/8	25
Allis Chalmers	29 3/4	22 1/8	28 7/8
American Chain & Cable	51	39 1/2	49
American Machine &Foundry	59 3/4	32 1/4	55
American Machine & Metals	70	47 1/2	69 1/2
American Optical	40 5/8	34 3/4	40 1/8
American Tel. & Tel.	202	167 7/8	200 3/4
Beckman Instruments	39 1/4	18 1/8	[illegible] 1/2
Bell & Howell	[illegible] 7/8	42	[illegible] 3/4
Bendix Aviation	66 1/4	44 1/2	63 1/4
Boeing Airplane	58 1/8	34 1/8	52 1/2
Bullard	18 1/2	10	[illegible] 3/8
Bulova Watch	14	[illegible] 3/4	13 1/2
Burroughs	40 1/2	27 5/8	37 3/4
Carborundum	39 3/8	30 7/8	38 1/2
Cincinnati Milling Machine	44 1/2	27	38
Clevite	24 1/2	15 3/4	[illegible] 3/8
Columbia Broadcasting A	41 1/2	24 1/2	39 1/4
Consolidated Electrodynamics	39	[illegible] 3/8	[illegible] 3/8
Consolidated Electronics	33 1/2	19 1/2	32 5/8
Cornell Dubilier	21 1/2	12 3/4	20 3/4
Corning Glass	95	74 5/8	88 3/4
Curtiss-Wright	31 1/2	20 5/8	27 1/2
Cutler-Hammer	63 1/2	40 1/2	63
Daystrom	39 1/4	30	33 3/8
Douglas Aircraft	74 7/8	54 1/2	58 1/8
Eastman Kodak	144 1/2	97 1/[illegible]	13[illegible] 7/8
Eaton Manufacturing	59	[illegible] 1/2	[illegible] 3/8
Electric Auto Lite	[illegible]	[illegible]	38 3/8
Elgin Watch	10 1/4	[illegible] 1/4	9 3/4
Emerson Electric	52 3/8	29	51
Food Machinery & Chemical	79	41 1/2	[illegible]
Gamewell	32 1/8	20 1/[illegible]	30 3/8
Garrett	44 1/2	[illegible]	42 1/8
General Controls	23 7/8	14	23 5/8
General Dynamics	[illegible] 5/8	[illegible]	[illegible] 5/8
General Electric	70 3/4	[illegible]	[illegible]
General Instrument	20 1/[illegible]	14 [illegible]	18 5/8
General Mills	85 7/8	60 1/4	[illegible]
General Precision Equipment	41	[illegible]	32 1/4
General Railway Signal	[illegible]	21 1/[illegible]	[illegible]
General Telephone	59 1/2	[illegible]	57 3/8
General Time	26 7/8	16 5/8	26 3/4
General Tire & Rubber	37 3/4	22 1/4	37 3/8
International Business Machines	[illegible] 1/2	[illegible]	[illegible]
International Tel. & Tel.	57 1/2	29 1/4	55 7/8
ITE Circuit Breaker	42 3/8	34 3/4	[illegible] 5/8
Litton Industries	[illegible]	[illegible] 7/8	81 1/2
Lockheed Aircraft	62 3/4	38 3/8	60
Magnavox	51 3/4	30 1/4	51
Mallory	34 5/8	23 5/8	32 1/8
Minneapolis-Honeywell	111	[illegible]	109
Minneapolis Mining & Mfg.	104	73 1/2	103 3/4
Motorola	54 1/4	35	54 1/4
National Acme	59 1/4	43 7/8	51
National Cash Register	76 3/4	50 1/2	72 1/4
North American Aviation	38 1/4	25 5/8	38 1/4
Northrop Aircraft	31 1/8	22 1/8	30 1/2
Otis Elevator	67 1/4	40 1/4	65 1/2

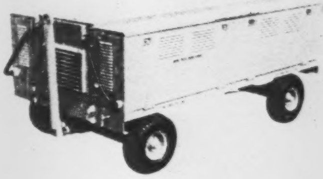
Continued on page 1928



High-flying, high-cost investments deserve protection. The best policy is pre-flight testing that checks out vital avionic systems on the ground . . . insures expensive ventures into space. Look to INET for the precise electrical power you can wheel right out on the flight line . . . in a single, custom-made package.

NEXT TIME...LOOK TO INET FOR PROVEN RELIABILITY

This INET unit was tailor-made for one of the latest Air Force Fighter-Interceptors. In seconds it brings to life all the avionic systems the plane will carry aloft. The unit provides eight power outputs for separately generated 1,600-cycle, 400-cycle, and DC power at closely regulated voltages for power supply, instrumentation checkout, and equipment testing.



▶ Engineers desiring a special reprint of the above cartoon should write to: "FLAME-OUT" c/o Inet Division of Leach.

INET DIVISION LEACH CORPORATION

18435 SUSANA ROAD, COMPTON, CALIFORNIA

DISTRICT OFFICES AND FIELD REPRESENTATIVES IN PRINCIPAL CITIES OF U.S. AND CANADA
EXPORT: LEACH CORPORATION, INTERNATIONAL DIVISION

For more information circle **24** on inquiry card.

MARSHALLTOWN

3
6
9
12
15
0
OUNCES

DIAPHRAGM GAUGE

FOR ACCURATE PRESSURE MEASUREMENT IN OUNCES OR INCHES OF WATER

Marshalltown Figure 83 is an extremely sensitive gauge that uses a carefully seasoned bronze diaphragm to accurately measure very low pressures. It is used extensively on many types of natural gas installations for checking low pressures.

Available in standard dials (reading in inches of water) 0-15" -0-30" -0-60" -0-100" -0-160" . . . also in ounce graduated dials from 15 ounces to 5 pounds. 2½", 3½" and 4½" dial sizes mounted in black enameled steel case.

Write for details and price. LOOK TO MARSHALLTOWN FOR ONE OF THE MOST COMPLETE LINES OF INDICATING PRESSURE GAUGES MADE!

MARSHALLTOWN MFG. COMPANY
MARSHALLTOWN 3, IOWA

For more information circle **25** on inquiry card.

New York Stock Exchange:

Continued from page 1926

Philco Corp.	24 7/8	12 3/8	22 7/8
Radio Corp. of America	42 3/8	30 1/4	41 1/4
Raytheon Mfg.	57 1/4	21 1/2	53 1/8
Reliance Electric	50 1/4	31	49 5/8
Rheem Mfg.	17 1/2	10 1/2	17 1/2
Robertshaw-Fulton	32 3/8	22 1/4	31 1/8
Royal McBee	25 1/4	16	21 3/4
Sangamo Electric	34 3/4	25	30 1/4
Sperry Rand	24 3/4	17 1/4	24 1/8
Square D	28 5/8	20 1/8	27 5/8
Standard Coil Products	14 1/4	8	14 3/8
Starrett (L.S.)	74 3/4	57	63 1/2
Stewart-Warner	45 1/4	29	44 3/8
Sylvania Electric	57 7/8	31 1/2	54 7/8
Telautograph	9 7/8	[illegible] 3/4	9
Texas Instruments	64 7/8	26 3/4	64 7/8
Thompson Ramo-Wooldridge	64 7/8	41 3/8	64 7/8
Tung-Sol Electric	42 1/4	23 1/4	30 5/8
Underwood Corp.	22	12 7/8	19
Union Carbide Corp.	120 [illegible]	83 7/8	119 1/2
United Shoe Machinery	[illegible] 5/8	32	43 5/8
Western Union	30 1/2	15	20 1/2
Westinghouse Air Brake	29 3/4	17 7/8	26 [illegible]
Westinghouse Electric	69 7/8	55 1/2	[illegible]
Worthington Corp.	48 1/4	45 1/4	[illegible]

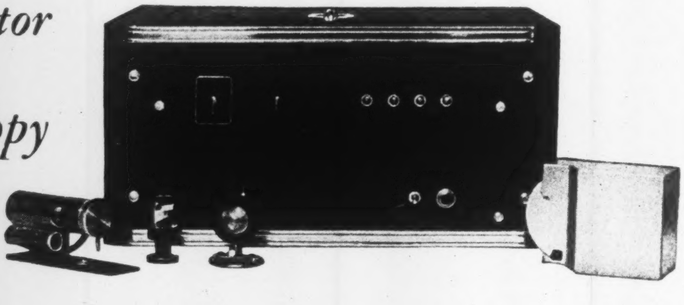
Over-The-Counter

OVER-THE-COUNTER

QUOTATION AS OF 11/18/58

	BID	ASKED
Aerovox Corp.	5 1/2	6
Aircraft Radio Corp.	26 1/2	30
Argus Corp.	29	29 3/4
Eitel-McCullough	29 1/2	30 1/2
Electronics Associates	43	44 3/4
Erie Resistor Corp.	9 1/4	9 3/4
Fisher Governor Company	15 7/8	16 5/8
Foxboro Company	40	41 1/4
G. M. Giannini	24 1/2	26 1/2
Industro Transistor	2 5/8	
Liquidometer Corp.	[illegible] 3/8	
W. L. Maxson	7 1/2	[illegible] 7/8
Penn Controls, Inc.	17 1/2	18 1/2
Speer Carbon, Inc.	29 3/4	30 3/4
Sprague Electric	32 3/4	34
Taylor Instruments	31 3/4	33
Telecomputing Corp.	6 1/2	7
Topp Industries	11 3/8	12
Varian Associates	35 1/4	37 3/4
Vitro Corp. of America	14 3/4	15 1/2

A Superior Detector for Infra-Red Spectroscopy



GOLAY PNEUMATIC DETECTOR

Among the characteristics that render the Golay Detector superior to other types of detectors for use in infrared spectroscopy are:

1. **An effective sensitive area 3/32" in diameter.**
2. **Sensitivity of 6 x 10^{-11} watts RMSENI when used with "chopped beam" method and with recording time constant of 1.6 second.**
3. **Uniform sensitivity from the ultra-violet through the visible and the entire infra-red, and up to the micro-wave region.**
4. **Improved, drift-free, A.C. operated amplifier with step gain controls and four response periods.**

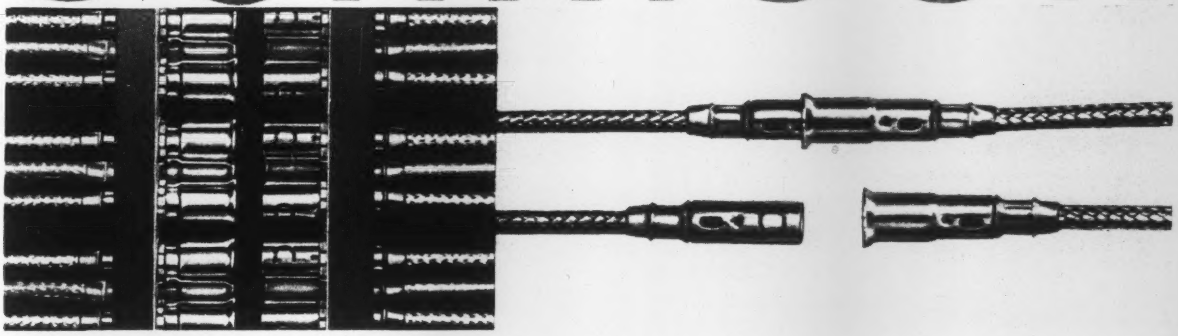
Write for EPLAB Bulletin No. 10

THE EPPLEY LABORATORY, INC.
SCIENTIFIC INSTRUMENTS
2 SHEFFIELD AVENUE, NEWPORT, RHODE ISLAND, U.S.A.

For more information circle **26** on inquiry card.

THE NEW CONCEPT IN COAXIAL DISCONNECT SPLICING...

COAXICON



Here is a totally new method for attaching disconnect splices to coaxial cables that will create new standards of performance . . . on chassis connections, computers, test equipment—in fact, anywhere that two coaxial cables need fast and reliable disconnect splicing.

Easily attached to coaxial cables by AMP's modern compression method, the all new A-MP COAXICON assures you of uniformity, absolute reliability and new low cost—in either free-hanging or through-panel units. In addition, the COAXICON supports cable shielding against vibration while offering fully insulated positive electrical performance.

Production rates easily exceed any method you're now using. With a simplified wire stripping method, it takes just one stroke of the matching A-MP tool to permanently crimp COAXICON to your coaxial cable.

Think of it—no more burned or melted insulation, no doubtful, sloppy connections, no time consuming, high-cost assembly methods. Once you've seen the all new COAXICON, you won't settle for less.

Send for a sample and complete product information today.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

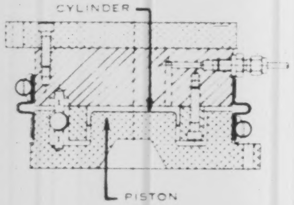
A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

For more information circle **27** on inquiry card.

briefs

Hydraulic Weighing

The basic principle of all Emery Hydraulic Weighing Systems is that of converting force into hydraulic pressure. This pressure is directly proportional to applied load and it can be transmitted to proper instrumentation to give indication, recording, printing or control.



To best describe the action of an Emery Hydraulic Cell, we refer to the well-known piston-cylinder action because in effect, an Emery Hydraulic Cell is a piston-cylinder assembly.

In any piston-cylinder there are three factors which must be controlled to insure accuracy: (a) leakage (b) friction and (c) acting area.

The acting area of the Way-pac Cell is always the same due to the ingenious molded diaphragm which is used as a pressure seal.—*(From new 16-page Bulletin, 582 The A. H. Emery Co., New Canaan, Conn.)*

For this literature circle **138** on inquiry card.

"Mini-Rapid 16" Automatic Processor

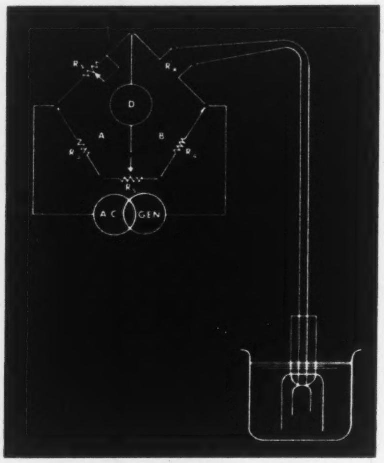
With the "Mini-Rapid 16" you can start to read film information just seven or eight minutes away from the shooting . . . you can shoot up to four hundred feet of film, drop it in the feed compartment of the Mini-Rapid 16—and see it come out, dry, (ready to show)—at the rate of 6 feet per minute . . . The negative, or release print is developed, fixed, rinsed, washed and dried automatically. You can process strips as short of two feet, or lengths up to 400 feet with one chemical loading . . . *(From new 4-page bulletin, Fairchild Camera and Instrument Corp., Industrial Camera Div., #5 Aerial Way, Syosset, L. I., N. Y.)*

For this literature circle **139** on inquiry card.

Solution Conductivity Measurement

The determination of conductivity consists of measuring the resistance of a column of solution. Alternating current is almost universally used in order to avoid changes in the composition of the solution adjacent to the electrodes, which effect comes under the general name of polarization. Although other measuring systems are in use, the a-c Wheatstone Bridge is most widely used at present and is potentially the most sensitive, stable and accurate. A typical system consists of three elements: an a-c Wheatstone bridge circuit, a primary element or conductivity cell, and a null indicator with or without a rebalancing mechanism.

Such a system is shown in Fig. 1. D represents an a-c voltage-sensitive device as an a-c. galvanometer, earphone, cathode-ray oscilloscope, or an electron ray "tuning eye" tube. The a-c source may be a low voltage tap on a 60 cycle transformer, a vacuum tube or transistor oscillator for higher frequencies, a dry cell operated vibrator, etc. The voltage varies among instruments of differing degrees of accuracy and sensitivity from several millivolts to as much as 50 volts. The frequency of the bridge current is commonly 60 and more rarely 1000 cps. For measurements on high resistance electrolytes, such as demineralized water and steam condensate, the lower bridge source frequency is preferable. For measurements in highly conductive solutions, higher bridge frequencies are advantageous.—*(From new 30-page Catalog 23, Industrial Instruments Inc., 89 Commerce Rd., Cedar Grove, N. J.)*



For this literature circle **140** on inquiry card.

Digitrol Building Blocks

This circuit uses standard "DIGITROL" components to establish a time base proportional to an analog voltage input V. The digitized servo output is used to preset a bank of decade counters. Since these counters are being fed pulses from the crystal clock at a uniform rate, the time from the beginning to the end of the counting operation is proportional to the preset quantity, and that in turn proportional to input voltage V.—*(From new 4-page bulletin Electro Precision Corp., P. O. Box 669, Arkadelphia, Ark.)*

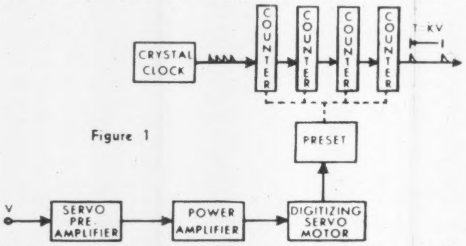


Figure 1

For this literature circle **141** on inquiry card.

Versatile stop clock measures to 1/100 second

Today's product designer, control systems engineer, nuclear physicist, and graphic panel manufacturer have a common need—an instrument capable of measuring elapsed time to a hundredth of a second, with an accuracy better than 0.02 of 1%.

Wide field—wide requirements

But there the sameness ends—the nuclear physicist needs a hermetically sealed device for remote control; the product designer requires load switches and local pushbutton reset; the graphic panel man wants smart appearance. The lab technician wants a portable model. The military asks for the smallest unit consistent with reliable readings, while the sports event timekeeper must have a large dial.

How can you meet these diverse requirements? Well, here's the answer to that question—a product of Cramer's experience and knowledge of precision timing.

Accuracy for everybody

You select a small, powerful and inherently accurate drive motor, add a 110-tooth positive clutch and apply it on the high-speed shaft. Back it up with a potent relay. When the signal comes, the unit responds instantly, and we have *accuracy*.

All-electric operation for flexibility

Add heart cams on the mainshaft and a rugged solenoid to belt them home within 1/10 second after the reset switch is operated. Now we have *electrical reset*, either remote or local.

For *versatility*, provide for load switches with cams on fast or slow pointer shafts. Cut and set at the factory, cams will offer a variable number (and duration) of pulses per second or minute, or with load switches wired in series, the unit can be used as a highly precise time delay relay or interval timer.

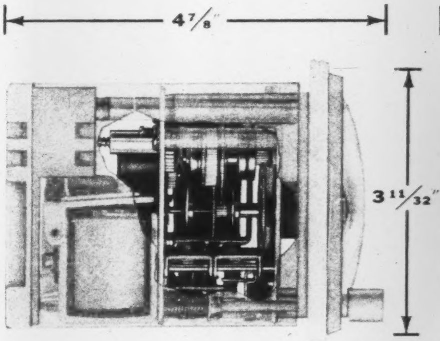
Commercial or Mil-Spec housings

Now let's enclose the mechanism. Commercial housing is dust-tight and has a 12-place terminal block. Also developed: a militarized model to withstand high vibration, shock and severe environments. A deep-drawn solder-sealed enclosure with 14-pin glass-beaded header, evacuated and hermetically sealed will do it.

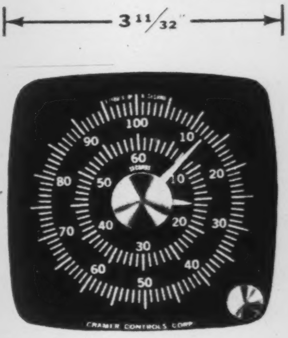
Dials, pointers — Loewy styled

What's left? The business end of things — dial and pointers. Let's tackle this for readability, and at the same time, shoot for eye-appeal. This time we'll go to the *styling* experts — famous industrial designers, Raymond Loewy Associates. They come up with the last word in human-engineered dial-pointer combination for fast, exact readings. Frame it with a pleasing bezel that can be finished to match or harmonize with your panels.

Now it looks like the precise instrument that it is — the new Cramer Type 691 Time Totalizer. Bulletin PB 691 tells more about it. For detailed information and complete specifications, write Cramer Controls Corp., Box 5, Centerbrook, Connecticut.



SIDE (phantom view)



FRONT

TYPE 691 PRECISION ELECTRICAL STOP CLOCK

	Total Range	Outer Scale	Inner Scale
		Each Division	Each Division
TIME RANGES:	60 sec.	.01 sec.	1 sec.
	60 min.	.01 min.	1 min.
	60 min.	1 sec.	1 min.

RATINGS: Motors — all standard voltages at 50, 60 and 400 cps, and 28 volts DC (chronometrically governed); clutches and solenoids — all standard voltages at 50 and 60 cps, and 28 volts DC.

ACCURACY: Within .01 second for 60-second units, and within .005 minute for 60-minute units.

ELECTRICAL RESET: Actuated either by momentarily pressing pushbutton on timer bezel, or by closing a remote switch. Timer pointers return to zero within 1/10 second.

LOAD SWITCHES: One or two, optionally available, SPDT, rated 5 amperes at 115 and 230 volts AC (resistive), 2 amperes at 28 volts DC.

CAMS: Optional, to operate load switches. Precision-cut to exact time specifications, they can provide a series of electrical pulses during timing, or transfer switch contacts at any point or points within the time range of the unit.

EXTERNAL CONNECTIONS: All connections to motor, clutch, reset solenoid and load switches are brought out to numbered terminals.

MIL-Specs: Hermetically-sealed military units meet vibration, shock and environmental requirements of MIL-E-5272A.

TALK IT OVER WITH

CRAMER CONTROLS
CORPORATION

For more information circle **28** on inquiry card.

JEWELS for INDUSTRY. . .

By MOSER JEWEL COMPANY,
pioneer industrial jewel
manufacturer for over 50 years.

- HIGHLY POLISHED STEEL PIVOTS AND STAFFS
- HARD ALLOY WELDED TIPS
- NON-MAGNETIC STAFFS
- DIAMOND POINTS

FOR INFORMATION ON HOW
WE MAY FILL YOUR REQUIREMENTS

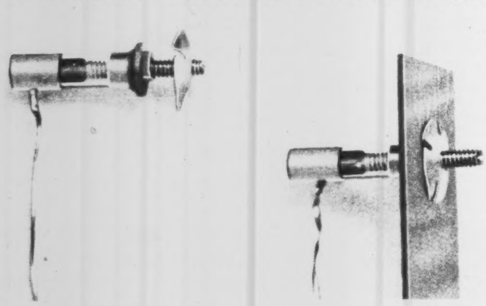
Write to . . .

MOSER JEWEL COMPANY
P.O. Box 150 • Perth Amboy, N. J.

"Manufacturers of all types of Industrial Jewels"

For more information circle **29** on inquiry card.

Direct - Traverse, Expanding - Core
MINIATURE TRIMMING CAPACITOR



Illustrated same size

Patented

Designed for the coming space age, the ATLEE Variable Capacitor operates on new electro-mechanical principles to give a much greater range and higher stability with less space and weight than ever before.

Only 25/32" long and 3/16" in diameter, its capacitance range is 0.5 to 5.0 mmf. Has micrometer adjustment. Available in glass dielectric and brass for standard panel mounting or quartz and invar for special applications.

A rugged unit, it will maintain a set value under extreme vibration and shock *without undue stress!* Has excellent retrace characteristics. Full-floating piston assures positive mechanical alignment, eliminating run-out.

ATLAS E-E CORPORATION
47 Prospect Street • Woburn, Massachusetts
3757 Wilshire Blvd. • Los Angeles, California

For more information circle **30** on inquiry card.

Intercom 1000

Developed especially for the Bendix G-15 General Purpose Digital Computer. . . . Intercom 1000 is a complete general purpose system, in which commands and data may be stored in the computer's internal memory . . . Each Intercom command is represented by a two-digit code. To write an instruction, the user need only specify the desired code, together with the four-digit memory address where he has previously stored the data on which he wishes to operate.

NOTES	Command Code	Memory Address
Perform square root subroutine, which begins at address 1597. Leave result in accumulator.	08	1597
Perform sine subroutine, which begins at address 1442. Leave result in accumulator.	08	1442

The calculation of any subroutine function may then be called for in a program with a single command. For example, the two commands below, added to the preceding program, would enable the computation in radians of

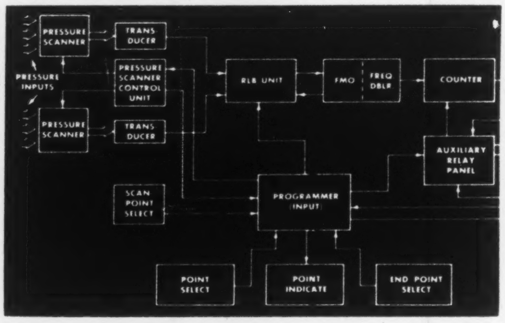
$$\sin \sqrt{(a^2-bc)/d}$$

(From new 4-page Bulletin AR-058-R-078, Bendix Computer, Div. of Bendix Aviation Corp., 5630 Arbor Vitae St., Los Angeles 45, Calif.)

For this literature circle **142** on inquiry card.

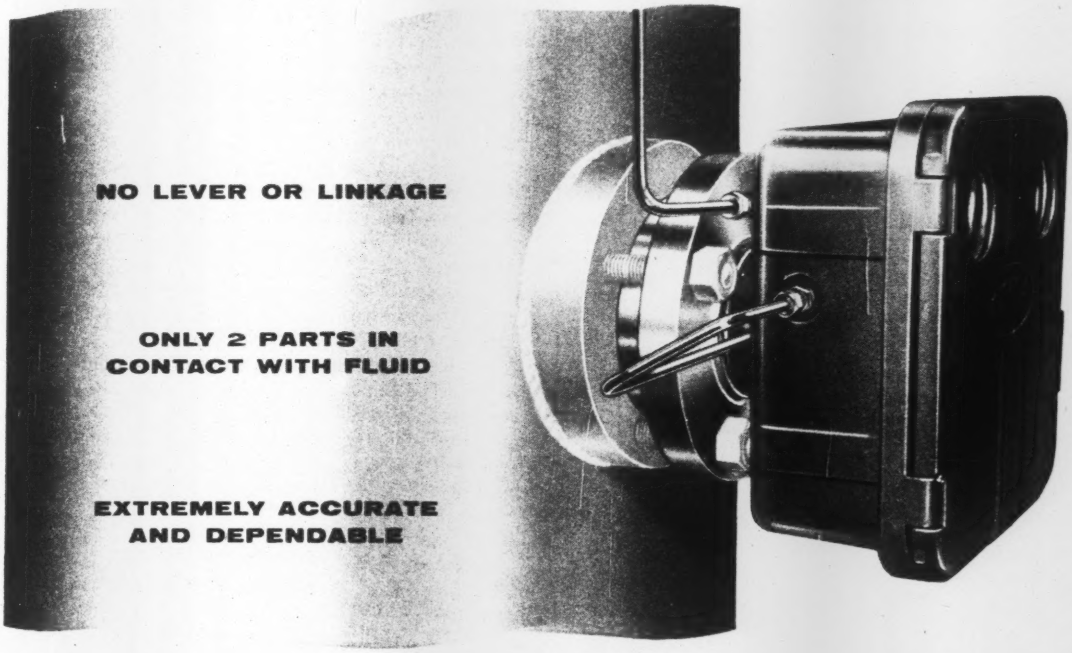
Pressure Scanner

The Data-Master Type 5 scans a number of pressures, measures them with high accuracy and records the data in digital form. It is particularly suitable when minimum switched volume is required for accuracy and speed. The Data-Master Type 5 is capable of higher accuracy, finer resolution and greater reliability than any other pressure logging system. The input pressures may be from small diameter probes or orifices and may be transmitted over considerable distances through small diameter lines. Connections are made to external fittings on the Data-Master console . . . (*From new 4-page bulletin, Hanson-Gorrill-Brian, Inc., 85 Hazel St., Glen Cove, N. Y.*)



For this literature circle **143** on inquiry card.

For that hard-to-handle liquid... consider the "115" Transmitter



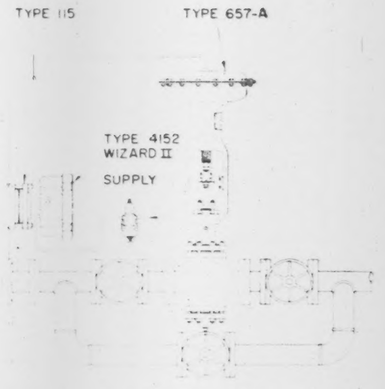
NO LEVER OR LINKAGE

ONLY 2 PARTS IN CONTACT WITH FLUID

EXTREMELY ACCURATE AND DEPENDABLE

Ideal as a liquid level transmitter for slurries, paper stock, and viscous or corrosive fluids

Flange mounts direct to side of tank. Only the diaphragm and the diaphragm ring come in contact with the fluid. Diaphragm is Teflon impregnated glass cloth ... ring can be stainless steel or some other corrosion resistant material of your choice. Pneumatic output of the "115" is a 1 to 1 measure of the liquid head in the vessel. Frequently supplied with the popular Fisher Wizard II as the controller which makes a complete and compact assembly for liquid level control application. Also used as a transmitter for remote, level indicating, recording or controlling. Primarily for open tank service, the "115" is used in pipe lines and vessels with pressures up to 75 psi. For complete information on the Fisher "115" write for Bulletin F-115.



Fisher "115" with the Wizard II as the controller on a liquid level control installation.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY

FISHER®
Controls

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England
CONTINENTAL EQUIPMENT CO. DIVISION, Coraopolis, Pennsylvania

SINCE 1880

For more information circle **31** on inquiry card.

MEASURE
actual air velocity
instantly with
Alnor VELOMETER

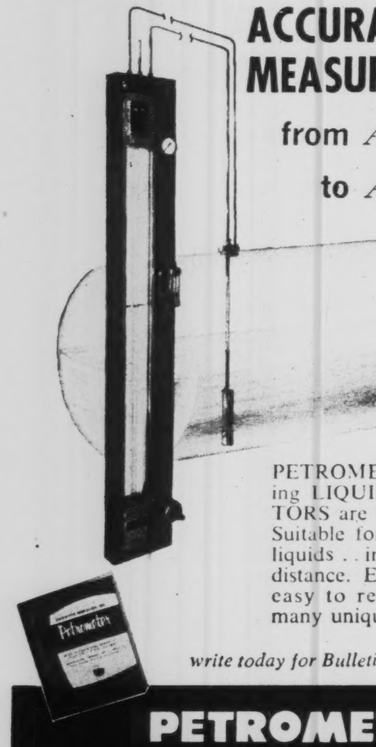
A simple, direct reading on the Alnor Velometer gives you an instant measure of air flow speed through grilles, ducts, furnaces, spray booths, or in the open.

Precision-built and self-contained, this portable instrument brings laboratory standards to the line or field installation. Available in a wide variety of scale ranges, full assortment of jets and fittings. You'll want all the facts (no safety department should be without a Velometer). Get Bulletin 2448-G. Attach this ad to your letterhead and mail to: Illinois Testing Laboratories, Inc., Room 518, 420 No. LaSalle St., Chicago 10, Illinois.

PRECISION INSTRUMENTS
FOR EVERY INDUSTRY

Alnor

For more information circle 32 on inquiry card.



ACCURATELY
MEASURES LIQUIDS
from ACETONE
to ASPHALT

PETROMETER Remote Reading LIQUID LEVEL INDICATORS are accurate and reliable. Suitable for all stored industrial liquids . . in any tank . . . at any distance. Easy to install . . . and easy to read. Indicators have many unique design features.

write today for Bulletin 6004.

PETROMETER
CORPORATION
43-22 TENTH ST. LONG ISLAND CITY 1, N. Y.

For more information circle 33 on inquiry card.

Precision Tuning Forks

These Precision Tuning Forks are intended primarily for applications where an accurate frequency source is required in a compact form . . .

In addition, a new order of accuracy of frequency over a wide temperature range is obtained in the W2003A and W2003 units by the use of temperature control. Heat is applied to the tuning fork at all temperatures below 20° C. This brings up the temperature of the fork to a relatively flat region in the fork temperature-frequency response. The design is such that full accuracy is attained in approximately 8 minutes in a minus 65° C ambient temperature.

The fork is made up of 2 metals which provide thermal compensation so that large frequency deviations do not occur due to temperature changes.

The working "Q" of the fork is greater than 6000. This assures a high stability of fork frequency with respect to external factors such as B voltage, tube aging, and change in component values.

The electrical circuit consists of a double triode amplifier with negative feedback applied through a non-linear element. This arrangement acts to maintain fork amplitude and therefore frequency constant when B voltage is varied, or if the circuit gain changes for any reason. . .

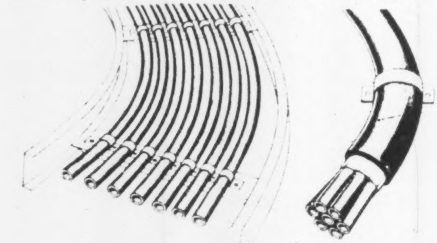
Output Voltage Approximately 5 V into 200,000 ohms or greater impedance.

Accuracy, Type R2003A: ± 1 part in 50,000 (± .005%) from + 15 to + 35° C. . . (*From new 4-page bulletin "Miniature Precision Forks, Types 2003A and 2003," American Time Products, Inc., 580 Fifth Ave., New York 36, N. Y.*)

For more information circle 144 on inquiry card.

Armored Instrument Tubing

An Okoflex assembly consisting of several cabled tubes can be installed in approximately the same time it takes to install one tube . . . armor protects the tubes from both physical damage and corrosion . . . cabled tubes (spiraled like the strands of a rope) can be bent on a small radius . . . colored sheaths provide "built-in" color coding . . . one tube in each layer of the tubing is color coded . . . communication or control wires can be cabled in with the tubes—for sound-powered phone communication during installation . . . (*From new 24-page Bulletin 1112, Okonite Co., Passaic, N. J.*)



7 single tubes 7 tube Okoflex cable

For this literature circle 145 on inquiry card.

Standard or special, simple or complex—

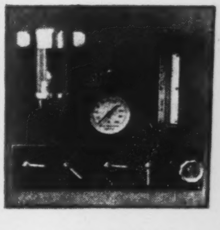
M-S-A Sample Systems and Accessories help produce unerring answers to your gas analysis problems

Proper handling of a sample stream can make a critical difference to the analytical instrument user. It may well be *the* determining factor in achieving positive results.

That's why the subject of proper sample handling has received so much emphasis at MSA. Already, we have spent thousands of engineering manhours on design, development, and testing of sampling systems and sample system components. Specifically, for use with M-S-A Infra Red, Thermatron, Oxygen, Combustible Gas, Water Vapor, and Carbon Monoxide Analyzers.

A great majority of the analyzers that we build have been supplied as part of a complete system, including all necessary sampling accessories. Because of the variety of sample conditions, a single system will not satisfy all requirements. Many MSA systems have been successfully applied so many times, however, that they have become standard. In other cases, we have developed special combinations of these standard units to handle problems peculiar to a certain application. Or, we have supplied individual components to a user where the application has not required an elaborate system.

An MSA Instrument Specialist can help you pinpoint the results you can expect from MSA Analyzers equipped with any or all of these versatile units. Our new bulletin, *M-S-A Sample Systems and Accessories for Gas Analysis* lists applications, features and advantages for the complete line. Write for your copy.

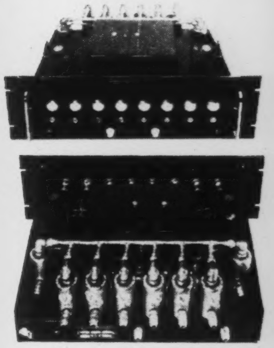

M-S-A Standard Systems

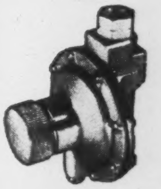
MSA
INSTRUMENT DIVISION
Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

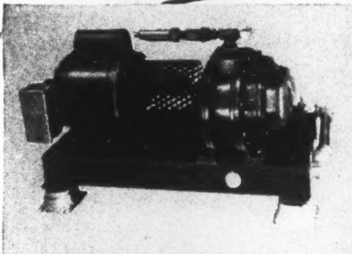
M-S-A Heavy Duty Primary Filter or Scrubber

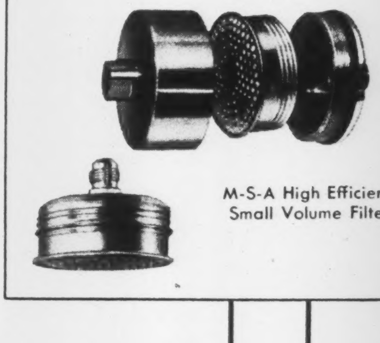
M-S-A Water Cooled and Air Cooled Sample Conditioners

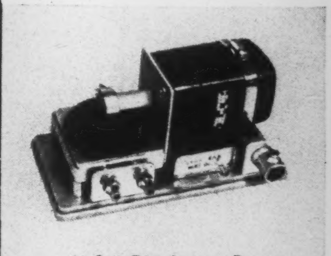
M-S-A Combination Filter and Liquid Separator


M-S-A Station Selector *Multipoint*


M-S-A Low Pressure Regulator

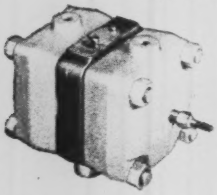

M-S-A Vacuum Pump and Motor Assembly


M-S-A High Efficiency Small Volume Filter

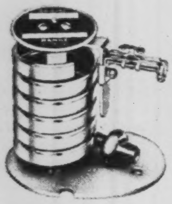

M-S-A Diaphragm Pump and Motor Assembly

For more information circle **34** on inquiry card.

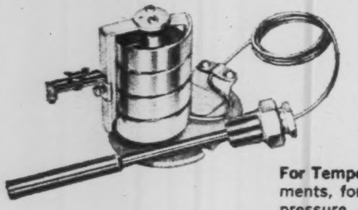
TYPICAL MOTION-TYPE TRANSMITTER MEASURING ELEMENTS



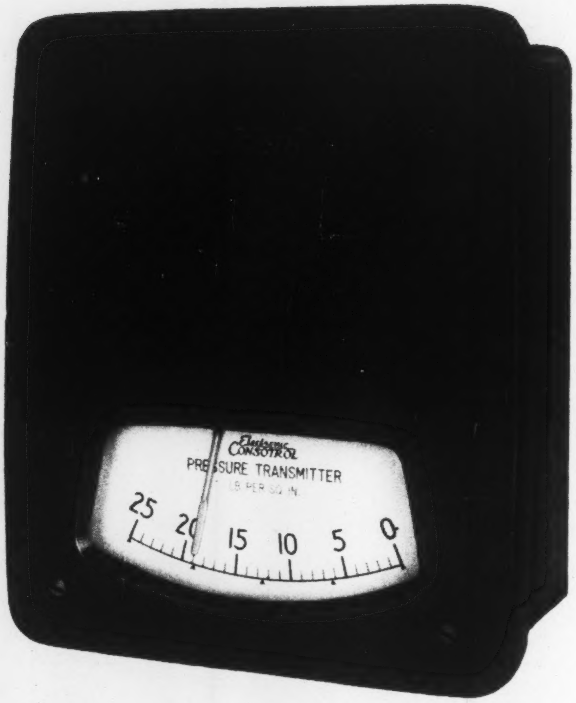
For Flow and Liquid Level — Type 37 Mercuryless Diaphragm Element. Ranges from 20 to 200 inches water.



For Pressure — Helical Elements, with ranges from 0-200 to 0-6000 psi. Ranges from 10 inches water to 80,000 psi available with other Foxboro pressure elements.



For Temperature—Helical Elements, for liquid filled, vapor pressure, and gas filled thermal systems.

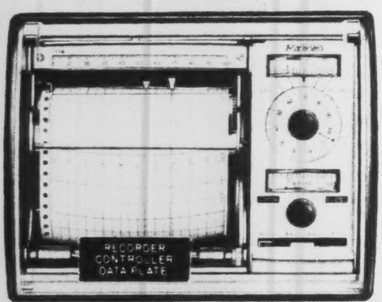


INDICATING TRANSMITTER—MOTION-TYPE

Electronic Transmitter measures flow, pressure, temperature, level, and other variables. Provides local measurement indication directly from the primary element—completely independent of electrical components and power supply. Transmitter uses any standard Foxboro measuring element. No tubes — solid-state components used throughout.

FOXBORO Electronic

REG. U.S. PAT. OFF.



COMBINED RECORDER-CONTROLLER

COMPLETE LINE OF RECEIVING INSTRUMENTS

Electronic Consotrol housing design permits unequalled flexibility in panel arrangement. Recorders and controllers can be enclosed in a 6" x 9" compound unit, as shown at left, or can be mounted separately — recorder in compact 6" x 6" case; controller in one slim 3" x 6" case. Regardless of mounting, controller operation is entirely independent of recorder, and both units pull out separately.

Electronic Consotrol Instrumentation also includes a full line of computing stations, valve actuators, ratio and cascade control systems, and alarms.

For more information circle **35** on inquiry card.

for the first time... the 100% solid state electronic system!

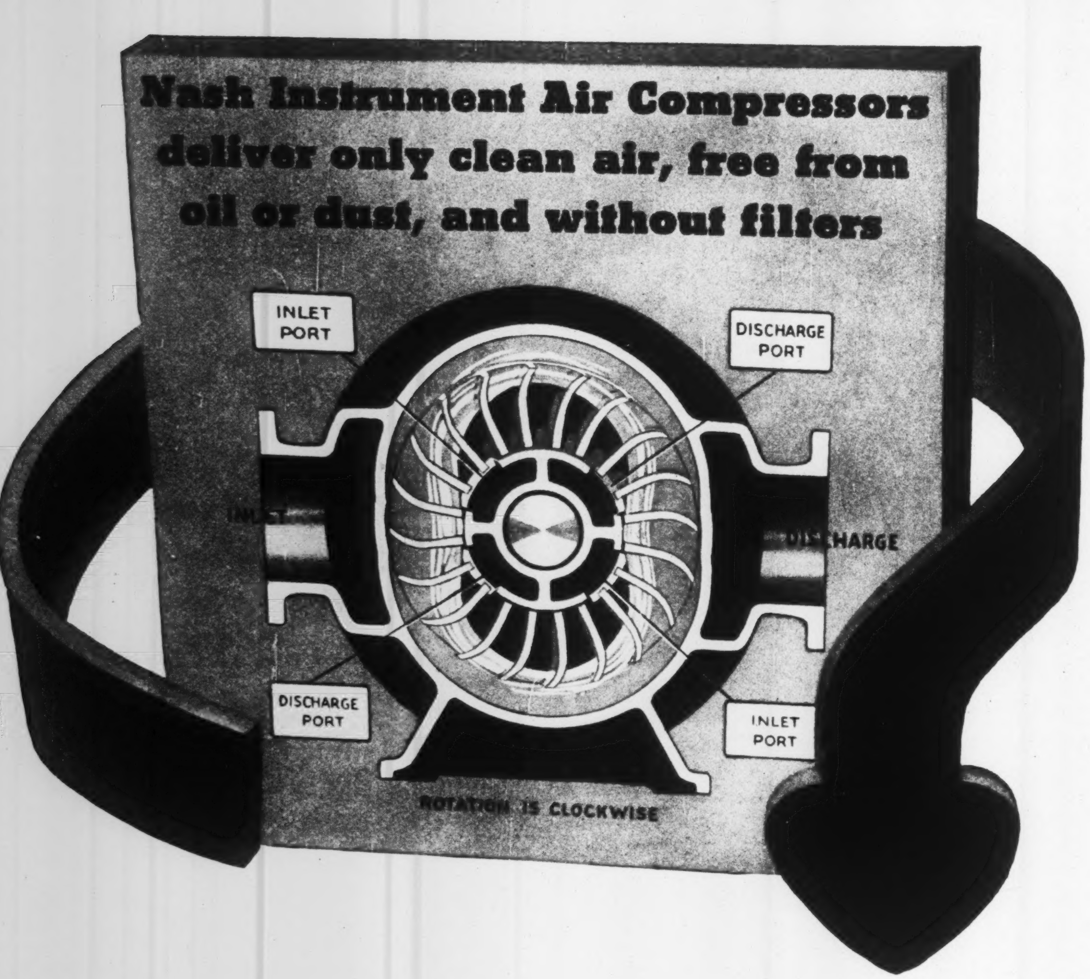
- thermocouple and resistance bulb converters–using magnetic amplifiers
- choice of force-balance and motion-type transmitters
- long time-constant tubeless controllers

Consotrol Instrumentation

Electronic Consotrol* Instrumentation — the most complete and advanced family of electronic-operated measurement and control instruments available today! That just begins to describe Foxboro's dramatic new advance in instrumentation. ✓ ✓ ✓ Foxboro electronic transmitters, indicators, recorders, control stations, computing stations, valve actuators and other final operators cover every function in the control loop. All are linked by a d.c. current signal. All are completely tubeless. Even thermocouple and resistance-type systems no longer require vacuum tubes. ✓ ✓ ✓ Electronic Consotrol systems convert temperature, pressure, flow, level measurement, etc., to a proportional signal at the transmitter. Transmission to a remote control station is instantaneous — using an electronic motion-type or force-balance transmitter. Designs are available for both hazardous and non-hazardous areas. ✓ ✓ ✓ Electronic Consotrol Instrumentation heralds a whole new era in process control engineering. Write Foxboro today for the new 32-page Catalog 21-10 which gives full details.

The Foxboro Company, 4612 Neponset Ave., Foxboro, Mass., U.S.A. *Reg. U.S. Pat. Off.

For more information circle 35 on inquiry card.


Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters
INLET PORT
DISCHARGE PORT
INLET
DISCHARGE
DISCHARGE PORT
INLET PORT
ROTATION IS CLOCKWISE

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

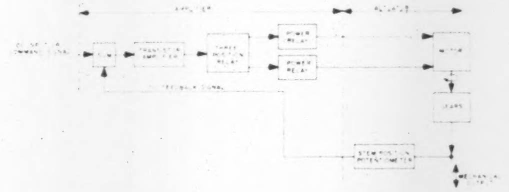
®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

All-Electric Positioner

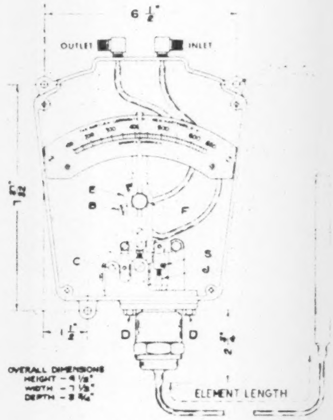
Input signal range may be 0-4 ma DC, 2-6 ma DC, or any intermediate range with a span of approximately 4 ma DC. The summing circuit compares this signal with a feedback signal generated by the stem position potentiometer which is geared directly to the mechanical output mechanism . . . If stem position exactly corresponds to the command signal, the two above mentioned signals effectively cancel each other at the summing unit, no error signal results . . . if the input is increased, the summing circuit sends a positive DC signal to the amplifier which sends a positive DC signal to the 3-position relay coil causing a set of contacts to close which will energize one of the two power relays. These in turn energize the actuator motor so that it moves the stem . . . (*From new 4-page Bulletin BV58-5, Norwood Controls Unit, Detroit Controls, 934 Washington St., Norwood, Mass.*)



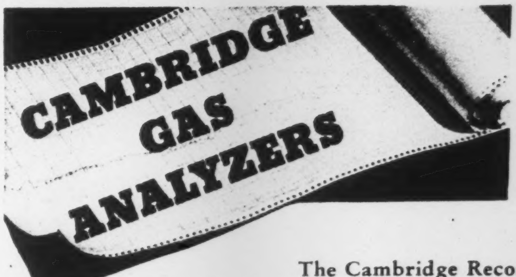
For more information circle **146** on inquiry card.

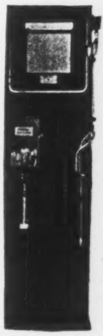
Temperature Controller

The Model IVA is extremely simple and positive in its operation . . . The thermal element operates on a mercury-expansion principle . . . As the mercury expands from an increase in heat at the sensing bulb, it actuates, thru simple lever action, the movement of the black indicating pointer . . . when the black pointer approaches the red setting pointer (enters into the throttling range) it actuates a tapered metering pin in a pilot air valve, reducing the air pressure to the remotely-placed air-operated fuel valve or other device . . . any slight temperature variation causes an immediate repositioning of the metering pin which is reflected by a change in air pressure to the fuel valve repositioning it to establish a new equilibrium position . . . (*From new 4-page Bulletin 342, Partlow Corp., New Hartford (Utica), N. Y.*)



For more information circle **147** on inquiry card.





The Cambridge Recording Gas Analyzer continuously analyzes and records as many as six constituents of a gas. Eliminates intermittent, slow and expensive manual gas analysis. Accurate . . . Sensitive . . . Simple. No moving parts; utilizes thermal conductivity principle.

Makes possible substantial savings in the operation of kilns, production of inert gases, and in metallurgical, petroleum, and other chemical processes. Single- and Multi-point instruments are available for a wide variety of applications.

Send for literature mentioning application

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Pioneer Manufacturers of
PRECISION INSTRUMENTS

For more information circle **36** on inquiry card.

THERE'S A BETTER WAY TO DO IT

FINDING THAT WAY IS AN IMPORTANT ACTIVITY AT LINDLY!

Research and Development is the only short cut to faster, better, more economical production.

The R & D facilities of Lindly & Company have earned international renown in the fields of photoelectric, infrared, optical, electro-mechanical and electronic techniques. *More than a score of Lindly-developed devices and systems have been developed for industrial and military applications. Many more are on the way.*

How can you profitably employ Lindly facilities as your R & D center or adjunct? A call or letter may be the first step toward finding that better way to do it in your own plant!

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LINDLY & COMPANY
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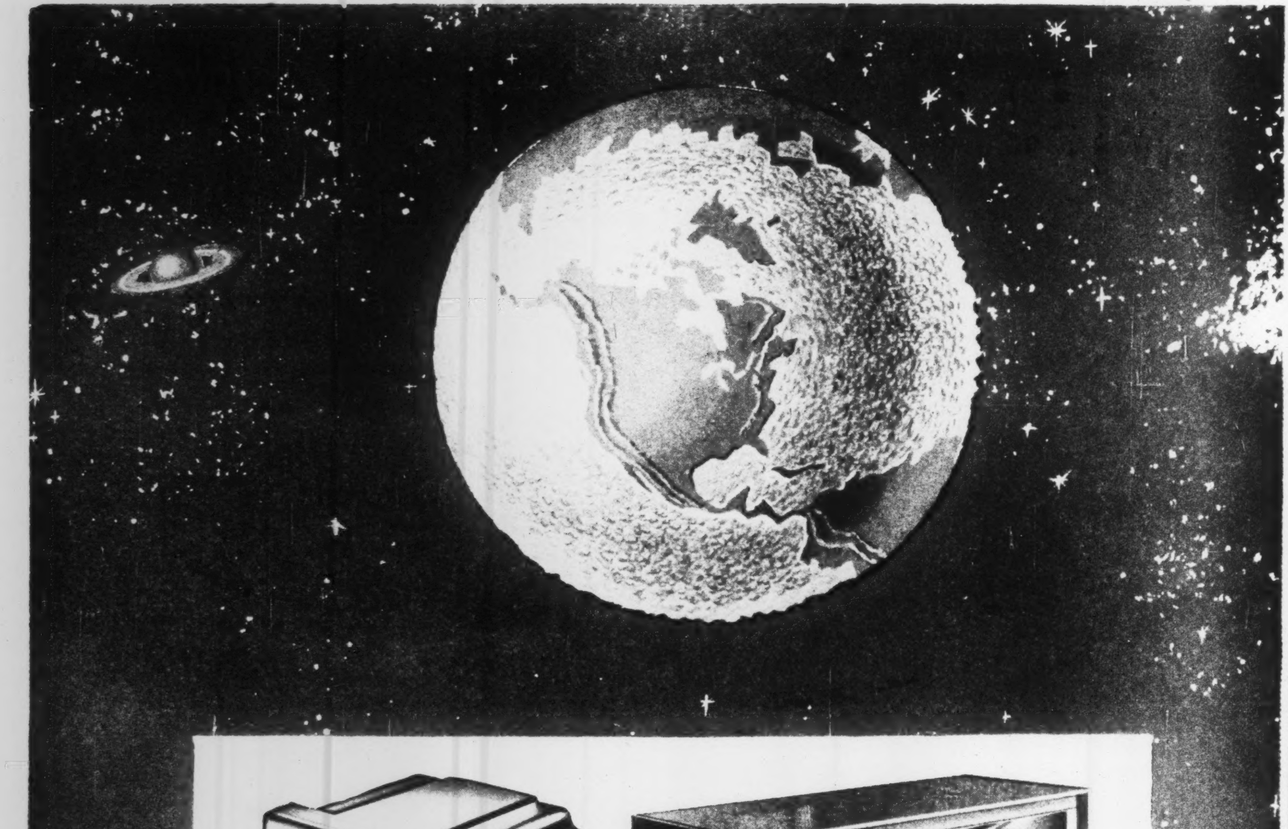
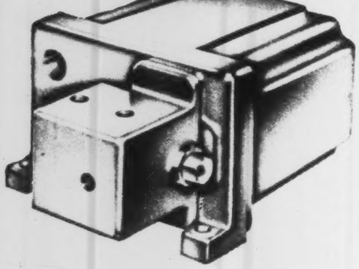
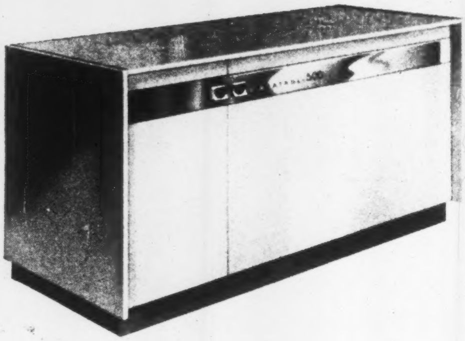
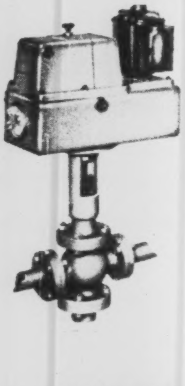
Pioneer 6-6505

For more information circle **37** on inquiry card.









Above, left—The GPE Controls Electric Flow Transmitter, a completely new idea in flow signal transmission. Completely transistorized, without complex mechanics, it transmits a high-level signal proportional either to flow or to differential pressure. Precise measurement and signal transmission are first in importance in good control.

Above—The Libratrol-500 Process Control System, made by Librascope and available to industry through GPE Controls, Inc., is developed around this highly reliable, rapid-response digital computer. It provides for a full range of process control—from accurate processing of data to provide understandable information to a human operator, to complete automatic control of an entire process or group of interrelated processes.

Left—One of many GPE Controls Electrohydraulic Valve Actuators that combine the speed and positive action of hydraulic valve operation with the flexibility of electrical control and signal transmission.

For more information circle **38** on inquiry card.

In the world of
INDUSTRIAL PROCESS CONTROLS...

tomorrow is already here!

What do you expect of tomorrow's automatic control systems? If you are looking forward to the advantages of computerized control systems . . . greater reliability in signal transmission . . . further localization of the control function, with centralized supervision . . . better response of final control elements . . . then for you tomorrow is already here.

GPE CONTROLS, Inc. brings to industry computer controls, components, and greater understanding of system dynamics – offered by several subsidiary companies of General Precision Equipment Corporation: *Librascope* for digital data-logging and closed-loop computer systems and associated components; *Kearfott* for high-performance hydraulic components and controls; *Link Aviation* for analog computer controls, product service, and manufacturing capabilities; *Askania* for more than 25 years of dealing with the control problems of industry.

GPE CONTROLS, Inc. welds together all these industrial control capabilities and makes them directly – and immediately – available to you.

Why not see what the engineers of GPE Controls can do for you? You'll be seeing this nameplate on the most exacting control-computer installations – soon and often.

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(Formerly, ASKANIA REGULATOR COMPANY)

Executive Offices and Midwest Regional Headquarters
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Western Regional Headquarters
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GPE Controls

GENERAL PRECISION EQUIPMENT CORPORATION

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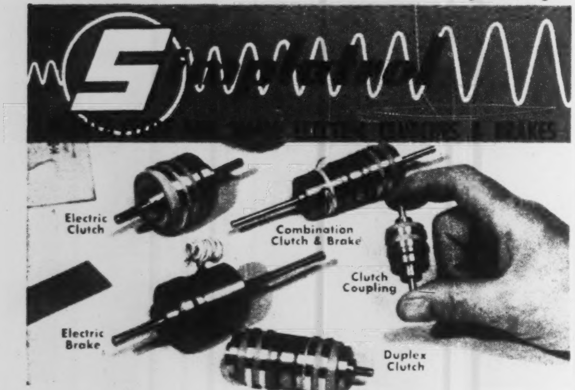
for AUTOMATED CONTROL, specify



Check the features of this new design:

- Rapid diaphragm action, no sliding parts
- Precise clutching and braking – adjustable "soft" to "harsh" action
- Simplicity in design, trouble-free operation
- Silent action, eliminates magnetization of surrounding parts
- 5 standard styles; full range of sizes — ⅞" to 3⅛" diameter

Check your requirements for electric clutch and brake control. You'll find SIMPLATROL Miniature and Small Electric Clutches and Brakes upgrade new machine performance, give faster, more precise sequence operations.

Ask for recommendations on Simplatrol units.
New illustrated folder on request.

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Representatives in Key Industrial Areas

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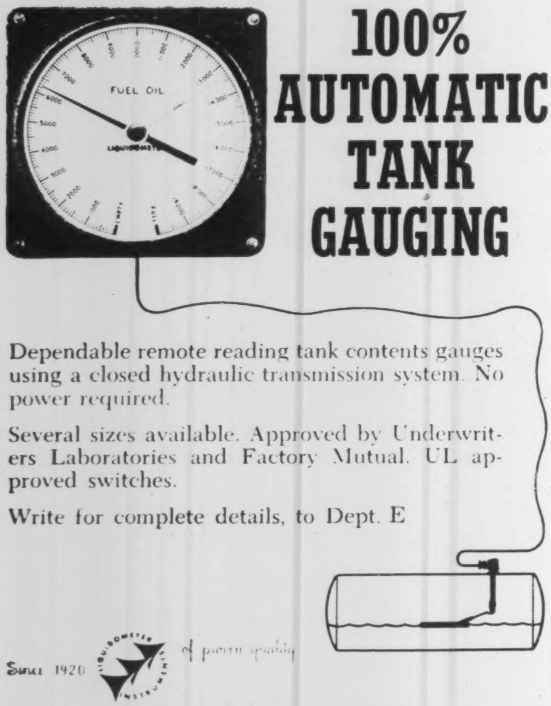


100% AUTOMATIC TANK GAUGING

Dependable remote reading tank contents gauges using a closed hydraulic transmission system. No power required.

Several sizes available. Approved by Underwriters Laboratories and Factory Mutual. UL approved switches.

Write for complete details, to Dept. E

Since 1920 of proven quality

THE LIQUIDOMETER CORP.
LONG ISLAND CITY 1, NEW YORK

For more information circle 40 on inquiry card.

Image Converter Camera Has 10^{-9} Sec Exposure

The Librascope Precision Technology Model C Image Converter Camera for photography of transient phenomena in the millimicrosecond region . . . designed around a newly developed image converter tube, is electrostatically focused and deflected. Exposure times to 10 millimicroseconds are possible with this camera . . . (*From new 2-page Bulletin "Model C Image Converter Camera," Librascope, Inc., Precision Technology Dept., 66 South P St., Livermore, Calif.*)

For this literature circle **148** on inquiry card.

Telemetering Filters

Telemetering filters are now available for every channel ranging from 400 cycles to 70,000 cycles and for various band widths between 15% and 40%. In addition to the standard case types which conform to the original JHU-APL specifications, special case sizes are also supplied . . . The tremendous advantage of these miniaturized filters can be seen from the fact that a set of the same twenty filters would have a volume of less than 300 cubic inches representing a reduction by volume of 80% . . . (*From new 16-page Catalog 104, Burnell & Co., Inc. 10 Pelham Parkway, Pelham, N. Y.*)

Freq	15% Band Width		30% Band Width		Case Size	Approx Weight	Attenuation	
	RDB Chan No	Type No	RDB Chan No	Type No	W L H		15% B W	30% B W
400 CPS	1	S-15456		S-25311	2 x6 x2¼	3 lbs	4DB—15% 20DB—23% 40DB—27%	4DB—30% 20DB—46% 40DB—54%
560 CPS	2	S-15457		S-15477				
730 CPS	3	S-15458		S-15478				
960 CPS	4	S-15459		S-25312				
1300 CPS	5	S-15460		S-25313	1⅜x4½x2¼	1 lb 7 oz	3.5DB—15% 20DB—23% 40DB—27%	3.5DB—30% 20DB—46% 40DB—54%
1700 CPS	6	S-15461		S-25314				
2300 CPS	7	S-15462		S-25315				
3000 CPS	8	S-15464		S-25316	1⅜x3 x2¼	9¾ oz	3DB—15% 20DB—23% 40DB—26%	3DB—30% 20DB—46% 40DB—52%
3900 CPS	9	S-15465		S-15479				
5400 CPS	10	S-15467		S-15480				
7350 CPS	11	S-15468		S-15481				
10500 CPS	12	S-15469		S-15482				
14500 CPS	13	S-15471		S-15483				
22000 CPS	14	S-15472	A	S-15484				
30000 CPS	15	S-15473	B	S-15486				
40000 CPS	16	S-15474	C	S-15487				
52500 CPS	17	S-15475	D	S-26066				
70000 CPS	18	S-15476	E	S-15488				
INPUT								

For this literature circle **149** on inquiry card.

Jackman-Van Winkle Integrator

The instrument is a tachometer feedback, velocity servo type integrator. The use of a mechanical differential as part of the servo link gives this integrator several advantages over similar integrators:

(1) The starting torque of the servo system is practically zero. Therefore the instrument has the same accuracy when integrating very near zero as when operating full scale.

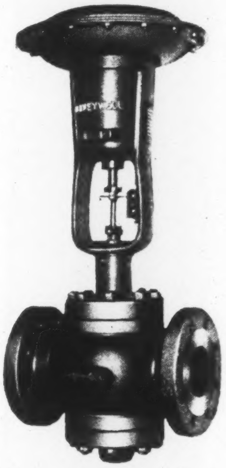
(2) The accuracy and linearity are improved over similar instruments.

Although the instrument is presently adapted to integrate the record of a strip chart recorder, it is easily adapted to integrate any mechanical motion or voltage input.

Dynamic rage is 52 db (*From new 2-page brochure, Research Appliance Co., P. O. Box 307, Allison Park, Pa.*)

For this literature circle **150** on inquiry card.

INFORMATION AT YOUR FINGERTIPS



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Now you can get a complete, easy-to-read reference on control valve technology.

A new, 88-page Honeywell catalog—generously illustrated with over 150 photos and drawings—gives performance, construction and application data on electrically and pneumatically operated control valves.

Completely cross-referenced, the catalog includes information on flow characteristics, valve sizing, corrosion . . . plus other valuable material important to every control valve user.

Fill out and mail the coupon . . . *without obligation*. And the next time you need control valves, call your local Honeywell field engineer. He's as near as your telephone. MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.

Minneapolis-Honeywell Regulator Co.
Valve Division
Fort Washington, Pa.

Please send me a copy of the new, 88-page Honeywell Control Valve Catalog C800-1.

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BIOGRAPHIES

of Significance

WILLIAM H. HANEY

Bill Haney received his engineering education at V. P. I. extension in Norfolk, Virginia, where he studied electrical engineering. Later he attended the U. S. Maritime School of Engineering and graduated in 1943 in marine engineering. For the duration of World War II he served as a maritime engineering officer.

Bill's interest in instrumentation began early in his high school days, around 1935, when he worked during vacation time in the jewelry business and had to repair some optical instruments. This "hobby" led to a job as instrument machanic, then others in the same line. He followed this occupation for several years before advancing his education.

When the war was over, Bill started his own instrument business. As president and general manager of a small corporation in New Orleans, Bill contracted instrumentation projects and custom-built instrumentation systems, and sold and serviced other instruments.

WILLIAM H. HANEY

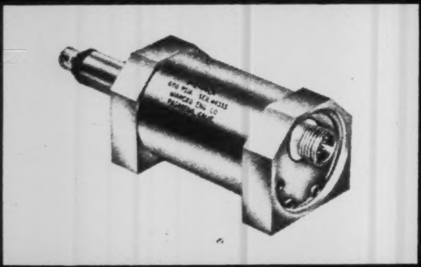
In 1946 he started the New Orleans Section of the ISA as a charter section, serving as its secretary for three years. The encouragement to start a section there came from Richard Rimbach, publisher of *Instruments*.

As to I&A, Bill says, "I am apparently a newcomer, having read your publication for only twenty years. Looking back to the time when your publication, *Instruments*, was the only source of information an instrument man had to find out what was going on in the instrument world about him, it seems, progresswise, like 150 years ago—but in reality it was only a few years . . ."

In 1955 Mr. Haney joined the Bechtel Corporation in San Francisco as a senior engineer in the instrument department. Three years later, in June 1958, he took a job with Chance Vought Aircraft, Inc., as systems engineer in electronic instrumentation design. He has been assigned recently to support engineering equipment for environmental testing and evaluation of missile inertial guidance systems.

Bill's biography shows the horizontal nature of instrumentation, making it possible for process instrument men to move into missile instrumentation, and *vice versa*.

a variable-reluctance pressure transducer for dc applications



Wiancko's new dc-dc pressure transducer is a notable advance in transducer design that will find ready acceptance and wide appreciation because here, combined in a small 10-ounce package, are all the advantages of the variable-reluctance pickoff with the desirable features of dc excitation and output. High output (0-5 volts dc), great accuracy and repeatability, exceptional acceleration and vibration resistance, constant output impedance, and high frequency response, all make this transducer eminently suitable for telemetering and data system applications.

Available in gage, absolute, and differential models, this new Wiancko achievement will soon be incorporated in accelerometers and force rings. For more detailed information, write for Product Bulletin 108.

wiancko

Wiancko Engineering Company
255 No. Halstead Avenue • Pasadena, California

Field Offices

• **Eastern**
No. 2 South Maple Ave.
Ridgewood, New Jersey
Phone: GIlbert 4-2444

• **Northern California**
Cowper-Hamilton Bldg.
Palo Alto, California
Phone: DAvenport 6-7053

• **Southern California**
3410 E. Foothill Blvd.
Pasadena, California
Phone: ELgin 5-7186

For more information circle **41** on inquiry card.

The Computer Handbook
edited by M. H. Aronson. A clear introduction to the entire field of electronic computers and data processors. Presentation by computer manufacturers at the Second Computer Clinic. Paperbound, 72 pages, 1956. **$2.00**

Process Control
by A. J. Young. A "must" for all who have to do with the automatic control of industrial processes, this book combines for the first time the practical "how" and the theoretical "why". Paperbound, 134 pages, 1957 (second printing). **$2.00**

Instruments Publishing Co., Inc.
845 Ridge Ave., Pittsburgh 12, Pa.

TIME
PROTECTO-PAC
METL-COR
1900°F
0
1000
2000
2500
3000
DEGREES

DEKORON PROTECTO-PAC

Advantages of Dekoron all-plastic instrument tubing harness are *now four-dimensional.* You get, in addition to its inherent lower-cost installation . . . chemical . . . impact . . . fire resistance.

And the advantages of Dekoron Protecto-Pac multiply the closer you examine them. For example, you can get Protecto-Pac in many forms to suit your requirements exactly — *from stock.*

If there is danger from weld splatter, sparks or a potential fire hazard — order Dekoron Protecto-Pac Type FB. If you wish to bury it underground — specify low-cost Protecto-Pac Type B. Both types supplied with virtually any number of individual tubes, and also with *new metal armor protection.*

You can pay more but you can't buy better, longer-lasting instrument line harness than *Dekoron — America's Premier Instrument Tubing Line.*

TYPE FB FOR FIRE AND IMPACT RESISTANCE

FIRE RESISTANCE of copper tube bundles is superior up to 1900°F, less pronounced from 1900° to 2500°F. Above 2500° Protecto-Pac Type FB is superior to copper tube bundle.

TYPE B FOR UNDERGROUND BURIAL

NO "CORKSCREW" effect, as with twisted tubes, because tubes lie straight in bundle to give faster, easier individual tube take-offs.

NEW IMPROVED INSULATION is composed of two wraps of asbestos tape bonded to backing of Mylar* for maximum protection.

DEKORON PROTECTO-PAC Type FB or Type B can be supplie with 24 gauge galvanized stee armor of modified square-loc construction with cord packing fo maximum strength and flexibil

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SAMUEL MOORE & COMPANY • DEKORON PRODUCTS DIVISION • MANTUA, OHIO

For more information circle **42** on inquiry card.

FREQUENCY STANDARDS

*3⅛" high
400 - 1000 cy.

PRECISION FORK UNIT
TYPE 50

Size 1" dia. x 3¾" H. Wght., 4 oz.*

Frequencies: 240 to 1000 cycles
Accuracies:—
Type 50 (±.02% at —65° to 85°C)
Type R50 (±.002% at 15° to 35°C)
Double triode and 5 pigtail parts required
Input, Tube heater voltage and B voltage
Output, approx. 5V into 200,000 ohms

FREQUENCY STANDARD
TYPE 50L

*Size 3¾" x 4½" x 5½" High
Weight, 2 lbs.*

Frequencies: 50, 60, 75 or 100 cycles
Accuracies:—
Type 50L (±.02% at —65° to 85°C)
Type R50L (±.002% at 15° to 35°C)
Output, 3V into 200,000 ohms
Input, 150 to 300V, B (6V at .6 amps.)

*3½" high
400 to 500 cy.
optional

PRECISION FORK UNIT
TYPE 2003

Size 1½" dia. x 4½" H. Wght. 8 oz.*

Frequencies: 200 to 4000 cycles
Accuracies:—
Type 2003 (±.02% at —65° to 85°C)
Type R2003 (±.002% at 15° to 35°C)
Type W2003 (±.005% at —65° to 85°C)
Double triode and 5 pigtail parts required
Input and output same as Type 50, above

FREQUENCY STANDARD
TYPE 2005

*Size, 8" x 8" x 7¼" High
Weight, 14 lbs.*

Frequencies: 50 to 400 cycles
(Specify)
Accuracy: ±.001% from 20° to 30°C
Output, 10 Watts at 115 Volts
Input, 115V. (50 to 400 cycles)

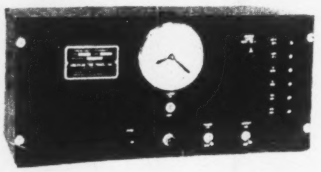
FREQUENCY STANDARD
TYPE 2007-6

NEW

TRANSISTORIZED, Silicon Type
Size 1½" dia. x 3½" H. Wght. 7 ozs.

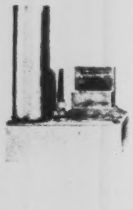
Frequencies: 400 — 500 or 1000 cycles
Accuracies:
2007-6 (± .02% at —50° to +85°C)
R2007-6 (±.002% at +15° to +35°C)
W2007-6 (±.005% at —65° to +125°C)
Input: 10 to 30 Volts, D. C., at 6 ma.
Output: Multitap, 75 to 100,000 ohms

FREQUENCY STANDARD
TYPE 2121A



*Size
8¾" x 19" panel
Weight, 25 lbs.*

Output: 115V
60 cycles, 10 Watt
Accuracy:
±.001% from 20° to 30°C
Input, 115V (50 to 400 cycles)

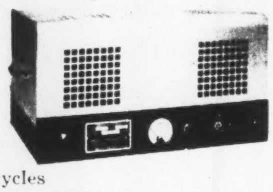


FREQUENCY STANDARD
TYPE 2001-2

Size 3¾" x 4½" x 6" H., Wght. 26 oz.

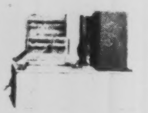
Frequencies: 200 to 3000 cycles
Accuracy: ±.001% at 20° to 30°C
Output: 5V. at 250,000 ohms
Input: Heater voltage, 6.3 - 12 - 28
B voltage, 100 to 300 V., at 5 to 10 ma.

FREQUENCY STANDARD
TYPE 2111C



*Size, with cover
10" x 17" x 9" H.
Panel model
10" x 19" x 8¾" H.
Weight, 25 lbs.*

Frequencies: 50 to 1000 cycles
Accuracy: (±.002% at 15° to 35°C)
Output: 115V, 75W. Input: 115V, 50 to 75 cycles.



ACCESSORY UNITS
for TYPE 2001-2

L—For low frequencies
multi-vibrator type, 40-200 cy.
D—For low frequencies
counter type, 40-200 cy.
H—For high freqs, up to 20 KC.
M—Power Amplifier, 2W output.
P—Power supply.

This organization makes frequency standards within a range of 30 to 30,000 cycles. They are used extensively by aviation, industry, government departments, armed forces—where maximum accuracy and durability are required.

WHEN REQUESTING INFORMATION
PLEASE SPECIFY TYPE NUMBER

American Time Products, Inc.

Watch Master
Timing Systems

Telephone: PLaza 7-1430

580 Fifth Ave., New York 36, N. Y.

For literature on TYPE 50 circle **43** on card.
For literature on TYPE 2003 circle **44** on card.
For literature on TYPE 2007 6 circle **45** on card.
For literature on TYPE 2001 2 circle **132** on card.

For literature on Accessory Unit TYPE 2001 2 circle **133** on card.
For literature on TYPE 50L circle **134** on card.
For literature on TYPE 2005 circle **135** on card.
For literature on TYPE 2121A circle **136** on card.
For literature on TYPE 2111C circle **137** on card.

events

January 12-14

Fifth National Symposium on Reliability and Quality Control, Bellevue-Stratford Hotel, Philadelphia, Penna. For information write William H. Rombach, Philco Corp., 4700 Wissahickon Ave., Philadelphia 44, Penna.

February 12-13

Cleveland Sec., IRE, Annual Cleveland Electronics Conference, Cleveland Engineering Society Bldg. For information write Harry Crows, S. Sterling Co., 5827 Mayfield Rd., Cleveland 24, Ohio.

March 2-6

Tenth Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Penn-Sheraton Hotel, Pittsburgh, Penna. For information write Fritz Will, Alcoa Research Laboratories, New Kensington, Penna.

March 3-5

Western Joint Computer Conference, IRE, AIEE, and ACM, Fairmont Hotel, San Francisco, Calif., Dr. Robert R. Johnson, Chairman, Write Box 381, Station A., Palo Alto, Calif.

March 18-20

Twenty-Second Annual Short Course for Superintendents and Operators of Water and Sewerage Systems, on campus of Louisiana State University. For information write Fred H. Dean, Louisiana State University, Baton Rouge 3, Louisiana.

March 23-26

I.R.E. National Convention, New York Coliseum & Waldorf-Astoria Hotel, N. Y. For information write W. C. Copp, IRE Adv. Dept., 72 W. 45th St., N. Y. 36, N. Y.

March 26

Fifteenth Annual Quality Control Clinic, Rochester Society for Quality Control, University of Rochester, N. Y. Write Earl D. Hogan, Eastman Kodak Co., Kodak Park Works, Eng. Div., Bldg 23, Rochester 4, N. Y.

April 6-7

2nd National Symposium on Chemical & Petroleum Instrumentation, St. Louis, Mo. For information write H. S. Knidler, ISA, 313 6th Ave., Pittsburgh 22, Penna.

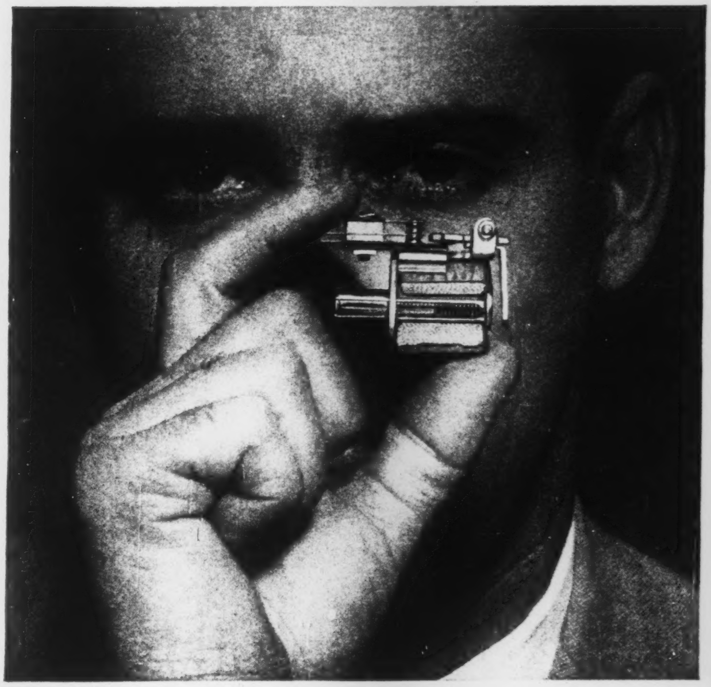
April 14-15

Conference on Industrial Instrumentation and Control, Illinois Institute Of Technology, Chicago, Ill. For information write R. W. Bull, Illinois Institute of Technology, 35 West 33rd St., Chicago 16, Ill.

November 16-20

Fifth International Automation Exposition, The New York Trade Show Building, 500 Eighth Ave., New York City. For information write Richard Rimbach Associates, Mgmt., 845 Ridge Ave., Pittsburgh 12, Penna.

COMPACT, 3-OUNCE TIME DELAY RELAY
with silicone-controlled
delay from 1/4 to 120 seconds



Worth a closer look . . . the Heinemann Type A Silic-O-Netic Relay. Despite its small overall size, the relay offers many big performance features.

For example, double-pole, double-throw switching . . . at fast snap-action contact speed.

The relay is a load carrier in itself: it may be energized continuously . . . does not require auxiliary lock-in circuits.

And it has a hermetically sealed time element that is forever free from the effects of aging or fatigue. The Type A Relay has proven itself in countless applications; it will give you reliable service over a long, long operational life.

BRIEF SPECS

Time Delays: from 1/4 to 120 seconds

Overall Dimensions: 2-1/16″ x 2″ x 1-9/16″

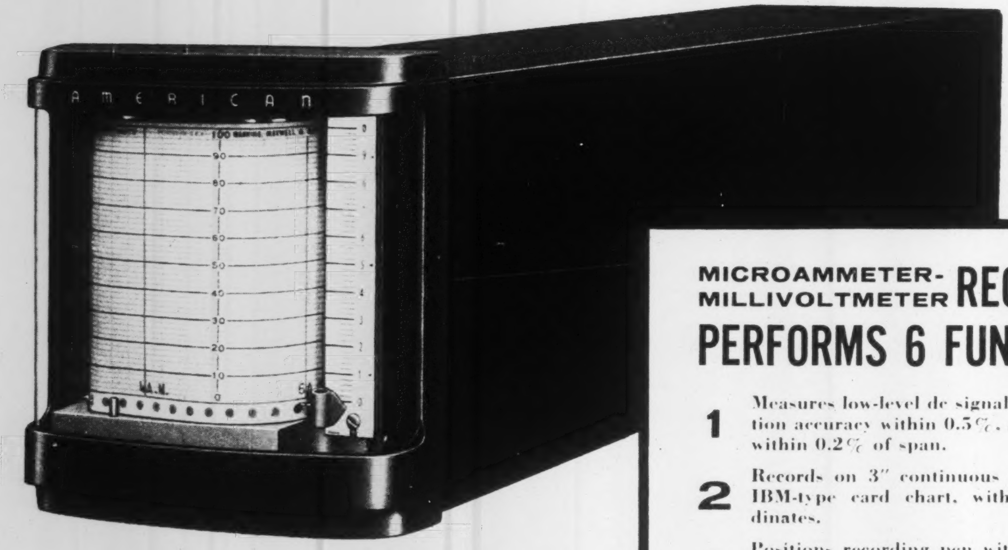
Contact Capacity: 3 amps at 120V AC, 1.5 amps at 240V AC (non-inductive load), 1 amp at 50V DC, 0.5 amp at 125V DC.

For full details, refer to Bulletin T-5002. A copy will be sent on request.

HEINEMANN
ELECTRIC COMPANY
162 Plum St., Trenton 2, N. J.

S.A. 1878

For more information circle 46 on inquiry card.



For only $250—
A More Accurate
HIGH-SPEED MILLIVOLT RECORDER

MICROAMMETER-MILLIVOLTMETER RECORDER PERFORMS 6 FUNCTIONS

1. Measures low-level dc signals with calibration accuracy within 0.5%, and sensitivity within 0.2% of span.
2. Records on 3″ continuous strip chart or IBM-type card chart, with linear coordinates.
3. Positions recording pen with force many thousand times greater than usual direct-deflection electrical movements.
4. Operates on force-balance principle—compensates for ambient conditions, changes in power supply and components.
5. Records fast—up to 0.05 seconds for 63% of fullscale changes.
6. Provides span and zero adjustments for easy calibration and zero suppression in the field, without special equipment.

This highly sensitive 'American-Microsen' Series 130 Recorder, with all its operational advantages, costs less than others designed for the same jobs. Simple design, precision components and rugged construction assure sustained high accuracy and freedom from maintenance. The recorder withstands shock up to 30 times gravity.

Since its introduction less than a year ago, the Series 130 Recorder has been very successful because it offers a more accurate and durable method of recording dc electrical signals at lower cost. It is being used to record outputs of many different electrical transducers – for measurement of such variables as pH, gas analysis, signal strength and others.

Many laboratories have adapted the Series 130 Recorder to their analytical and scientific instruments to assure accurate, permanent records of results which previously were only indicated. The Recorder can be used with any device which can provide 200 microamperes or more in its output circuit.

Standard 'American-Microsen' Series 130 Recorders are priced at $250.00. All models have ample power to operate alarm contacts which can be supplied at extra cost. *Write for Bulletin MG10.*

SPECIFICATION BRIEFS

POWER SUPPLY: 115 volts, 60 cycles. **POWER REQUIREMENT:** 9 watts.

INPUT RANGES: Voltage – 0-20 millivolts to 0-100 volts dc. **Current** – 0-200 microamperes to 0-100 milliamperes dc. **Input Sensitivity** – 6700 ohms per volts.

ACCURACY: ± 0.5% of span. **SENSITIVITY:** ± 0.2% of span.

REPEATABILITY: ± 0.25% of span.

EFFECT OF SUPPLY VOLTAGE: Less than 0.5% error 90-130 volts.

EFFECT OF AMBIENT TEMPERATURE: Less than 0.5% error 50° to 100° F., and less than 1% to 130° F.

RESPONSE TIME: Fast Speed – 0.2 seconds standard for 63% of fullscale input change; up to 0.05 seconds for 63% on special order. **Slow Speed** – approximately 4 times fast speed setting.

CHART SPEEDS: Strip Chart – 1″ per hr., standard; 3″ or 6″ per hr. available. **Card Chart** – 1 rotation per day, standard.

SPAN ADJUSTMENT: ± 10% of span. **ZERO ADJUSTMENT:** ± 100% of span.

PANEL SPACE REQUIRED: Only 27 square inches.

MAXWELL
MANNING
M&M
& MOORE INC.
TRADE MARK

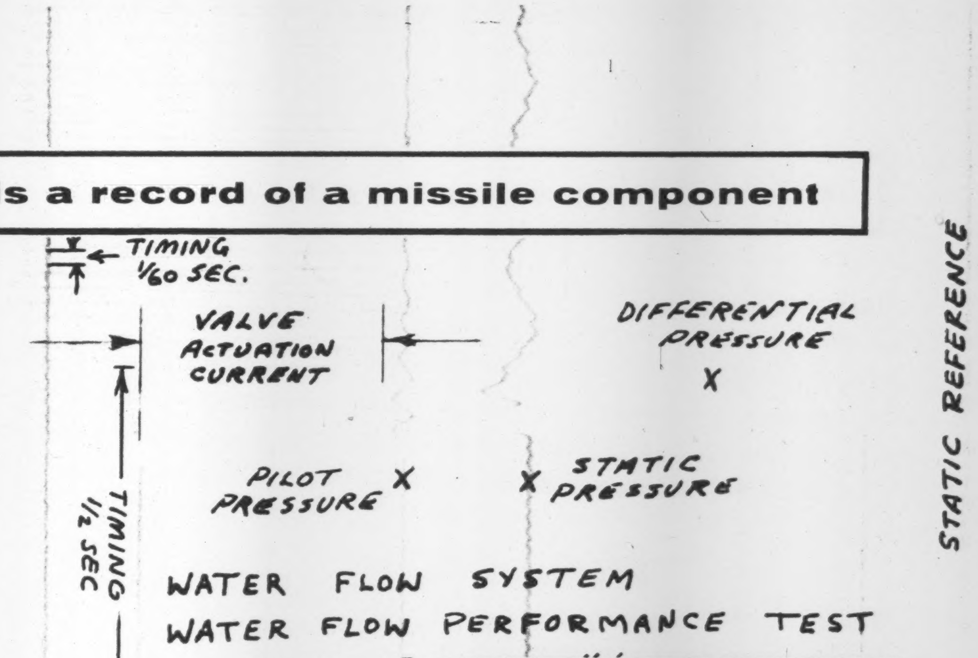
MANNING, MAXWELL & MOORE, INC.

INDUSTRIAL CONTROLS DIVISION · DANBURY, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC INSTRUMENTS FOR MEASUREMENT, TRANSMISSION AND CONTROL

For more information circle **47** on inquiry card.

This is a record of a missile component

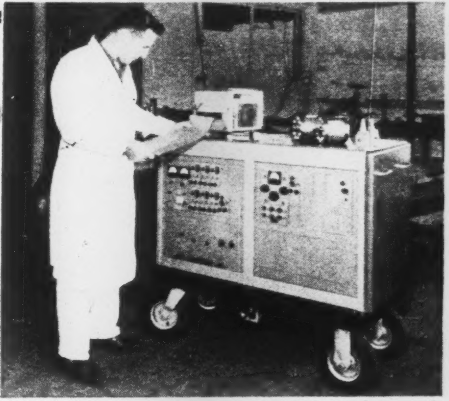


Visicorder Record—actual size

Wyle Laboratories in El Segundo, California, have used a battery of four Visicorder consoles like the one shown *(right)* to run a series of tests on a vital missile component. In the Wyle test project, the unique Visicorder consoles are easy to operate. Most parameters are low frequency, requiring response on the order of 5 to 60 cycles.

The two calibrator control panels in each Visicorder console accommodate 10 plug-in balance and matching units—designed to match tachometer generators, pressure transducers, thermocouples, expanded-scale voltmeters, etc., to the Heiland galvanometers.

Dick Johnson, Instrumentation Branch Head at Wyle, says, "This system, I feel, is one of the most efficient instrumentation consoles in operation. Set-up and calibration time has been reduced by the use of Visicorders by approximately 50%. This is due to the simplicity of operation and trouble-free performance. There are no inking pens to clean, high-gain amplifier maintenance, and so on, and we can also use these consoles together to form systems of more than six channels."



Tom Jackson, Wyle engineer, examines Visicorder record

The HONEYWELL VISICORDER is the first high-frequency, high-sensitivity direct recording oscillograph. In laboratories and in the field everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Honeywell

Industrial Products Group

Reference Data: Write for Visicorder Bulletin

Minneapolis-Honeywell Regulator Co., Industrial Products Group, Heiland Division, 5200 E. Evans Ave., Denver 22, Colorado

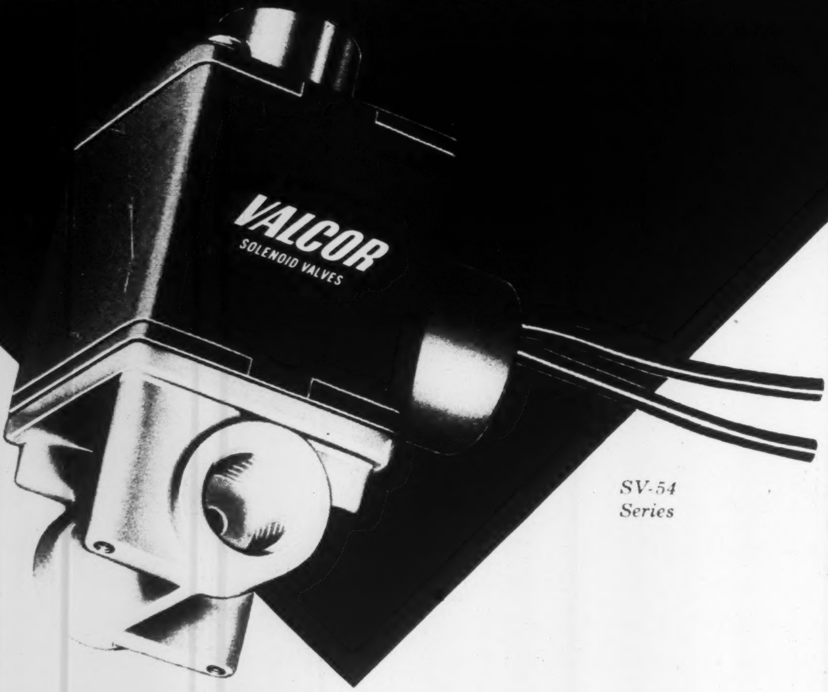
For more information circle **48** on inquiry card.

New 3-Way Nylon-Body Solenoid Valve...

List Priced as Low as $10.75...

(Quantity Discounts Available)

Outlasts, Outperforms Steel!



SV-54 Series

VALCOR'S new 3-way Nylon solenoid valve, SV-54 Series, outlasts and outperforms steel, yet is list priced as low as $10.75! In general purpose and O.E.M. installations, where millions of operating cycles are essential, this new Valcor valve not only works best but costs less.

Its nylon seat outlasts steel... its port threads outlast steel . . . pound for pound it's *3 times stronger than steel.* Dry seal threads, no compound is needed—and they won't loosen even under severe vibration. Nylon is non-corrosive so you have no atmospheric problems. And the stainless plunger is a reliable workhorse for millions of cycles. Bubble tight sealing. Available in normally open, normally closed and "directional control" configurations in all normal AC and DC voltages... 1½" square x 3" long (valve illustrated).

Write today for complete technical data on this shock-resistant, pressure-proof valve—the 3-way nylon-body valve, SV-54 Series, that's 3 times stronger than steel, yet costs less. Try it on your toughest application.

VALCOR
SOLENOID VALVES

VALCOR ENGINEERING CORP.

5366 Carnegie Avenue, Kenilworth, New Jersey

For more information circle **49** on inquiry card.

Panhandle Pete

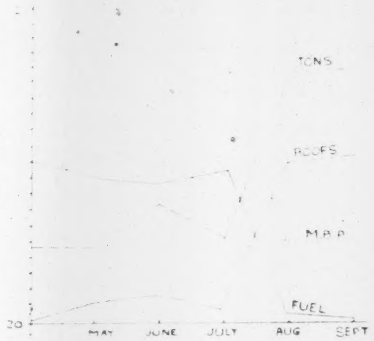
FANTASIA UNLIMITED

"CUZ," says Waldo Klappsaddle, Sales Manager of WESCO!, "We have the world by the well-known place with our latest fantastic, fabulous and filosophic Model TR System Analyzer Computer-Controller." Waldo was holding his first press conference since his return from a wild-cat trip into central West Virginia where he has been running down a rumor of a new ramp plantation. Waldo has also just received a rare honor: he is the first man locally to receive the $50 Reward for "Information leading to the arrest and conviction of anyone stealing a push-cart from the Long Bottom A&P store" (his wife inadvertantly pushed one home one evening). As a consequence, Waldo is back to his old genial self.

"What do you mean, Waldo?" asked I, smelling another "first" in the instrument industry. "What's happened now?"

"Well you won't believe this, Cuz, but we have installed the TR System Analyzer on No. 501 Open Hearth up at the West Virginia Electronic Coke and Petroleum Company and turned it loose to start saving money for them. At this point Waldo reached around into the book case for the latest trade magazine to search for additional adjectives to enliven his description of TR, but, failing to discover what he was looking for, whipped out a graph which illustrates the wondrous results.

"See Cuz, how the Tons per Hour have been poking along until July?



See how they jumped up during July? Why one can just stand there and see the arteries of commerce throbbing with new hope. Look at the Fuel Rate! We have already had a visitor from the Oil Trust. He said we'd either have to quit making this analyzer or else they would have to raise the price of fuel oil. And Roof Life? Listen, there was a. . ."

"What's that dotted line marked M.B.P.? I never saw that on open hearth reports," asked I, breaking in on Waldo's monolog.

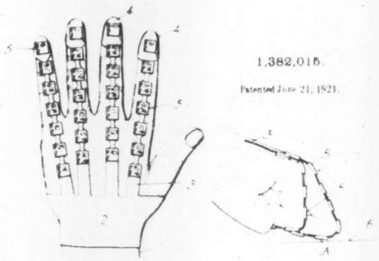
". . . delegation from the brick industry who threatened me bodily injury if . . . huh? Oh, that? That line is a plot of the Manager's Blood Pressure. You can see how jumpy he was up until the time we started the analyzer and how smooth it was afterwards . . ."

"But Waldo, what happened shortly after the first of September? The line drops straight down?" I interjects.

"Yes, a very sad case. Tsk, tsk, tsk." Here Waldo picked his teeth reflectively. "Yep, that was the day that the bill for the TR plus the operating cost came in. The poor fellow dropped dead."

Panhandle Pete

Weight Automation



"The principal object of my invention is to provide for weighers in biscuit-making, cake-making and other establishments, a rapid weight stamper by which boxes and cans may be quickly and efficiently stamped by a less number of employees than are now required for that purpose. The stamper can be easily attached to the back of the fingers and the wrist, to permit any one of a series of rubber stamps to be instantly brought to a position by a bending movement of a finger on the back of the hand to stamp any weight desired on a box, can or other object."

James W. Rudolph
Patent 1,382,015
June 21, 1921

For your library . . .

Printed Circuitry

by Allan Lytel. A valuable working tool; includes alternative and recommended practice for each step in design and production of printed circuits; a buyer's guide to special components; and "how to" service data. Paperboard, illustrated, 192 pages, 1957. $2.00

Maintenance and Servicing of Electrical Instruments

by James Spencer. Useful to all instrument users, service men, switchboard attendants testing engineers, and others, this book covers construction, testing, applications, principles of operation and maintenance of all kinds of electrical indicating instruments. Clothbound, 274 illustrations, 280 pages, 1951 (third edition). $2.00

Process Control Analysis

by M. H. Lajoy and E. A. Baillif. An essential first step in analysis of closed-loop controlled processes via frequency response of the system. Clothbound, 72 pages, 1956. $2.00

The Computer Handbook

edited by M. H. Aronson. A clear introduction to the entire field of electronic computers and data processors. Presentations by computer manufacturers at the Second Computer Clinic. Paperbound, 72 pages, 1956. $2.00

Process Control

by A. J. Young. A "must" for all who have to do with the automatic control of industrial processes, this book combines for the first time the practical "how" and the theoretical "why". Paperbound, 134 pages, 1957 (second printing). $2.00

Operation and Care of Circular-Scale Instruments

by James Spencer. Includes "trouble" charts for d-c, and for a-c instruments; covers d-c instruments, a-c ammeters and voltmeters, wattmeters, frequency meters, power factor meters and synchroscopes. Clothbound, 90 pages, 1949. $1.50

Control Valves

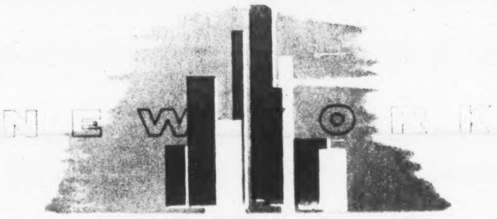
by C. S. Beard. New "one-book" reference on control valves . . . covers flow characteristics; mechanical features; valve capacity; sizing; body types; positioners; actuators, including d-c, electrohydraulic and gas hydraulic actuators. Numerous tables and illustrations. Paperbound, 236 pages, 1957. $2.00

Instruments Publishing Co.

845 Ridge Avenue
Pittsburgh 12, Pa.

"the show of the future"

FIFTH
INTERNATIONAL
automation
EXPOSITION



NOVEMBER 16-20, 1959

Plan **NOW** to exhibit at the Fifth International Automation Exposition

As the nation's leading "automation" show, the Fifth International Automation Exposition is ideal for displaying equipment, components, and systems associated with industrial and scientific instrumentation, machine-tool control, computing, data and materials handling, and conveying.

Scheduled for November 16 to 20, 1959, at the New York Trade Show Building, the Exposition will again attract thousands of top executives and technical personnel from all industries.

Unique features of the New York Trade Show Building enable all exhibitors to schedule "clinics" for instructing selected audiences on the fine points of their equipment . . . in complete privacy . . . and featuring the equipment itself!

Make room now, in your promotion budget, for this most important show. Write for full details, and breakdown of attendance at previous International Automation Expositions.

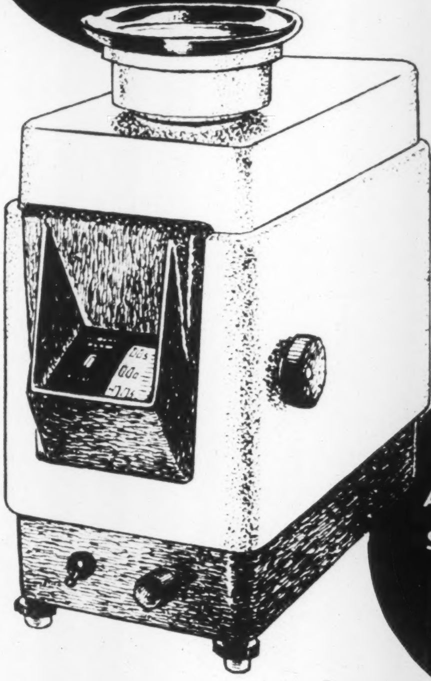
Richard Rimbach Associates, Management
FIFTH INTERNATIONAL AUTOMATION EXPOSITION
845 Ridge Avenue, Pittsburgh 12, Penna. Phone FAirfax 1-9831 and 1-9832

Mettler PRESENTS

2 BALANCES IN 1

1

A STRAIGHT BALANCE FOR ALL CONVENTIONAL WEIGHINGS



The METTLER precision balance type K-7T/12 is a very useful and versatile instrument for the control laboratory. It does double duty.

It serves as a very efficient and fast scale for weighings to a capacity of 800 grams. A built-in taring device permits easy taring of containers to the full 100 gram range of the optical scale. Precision: ±0.03 grams.

At other times it is a highly effective "over-under" scale. The optical scale is dyed red below the zero mark and is graduated for minus readings in the red range. By using the built-in mechanical weights and taring device any quantity up to 800 g can be made to read zero on the scale. This places the break in color—from clear to red—right in the middle of the viewing screen. Deviations can be read quickly to an accuracy of 0.02 grams.

2

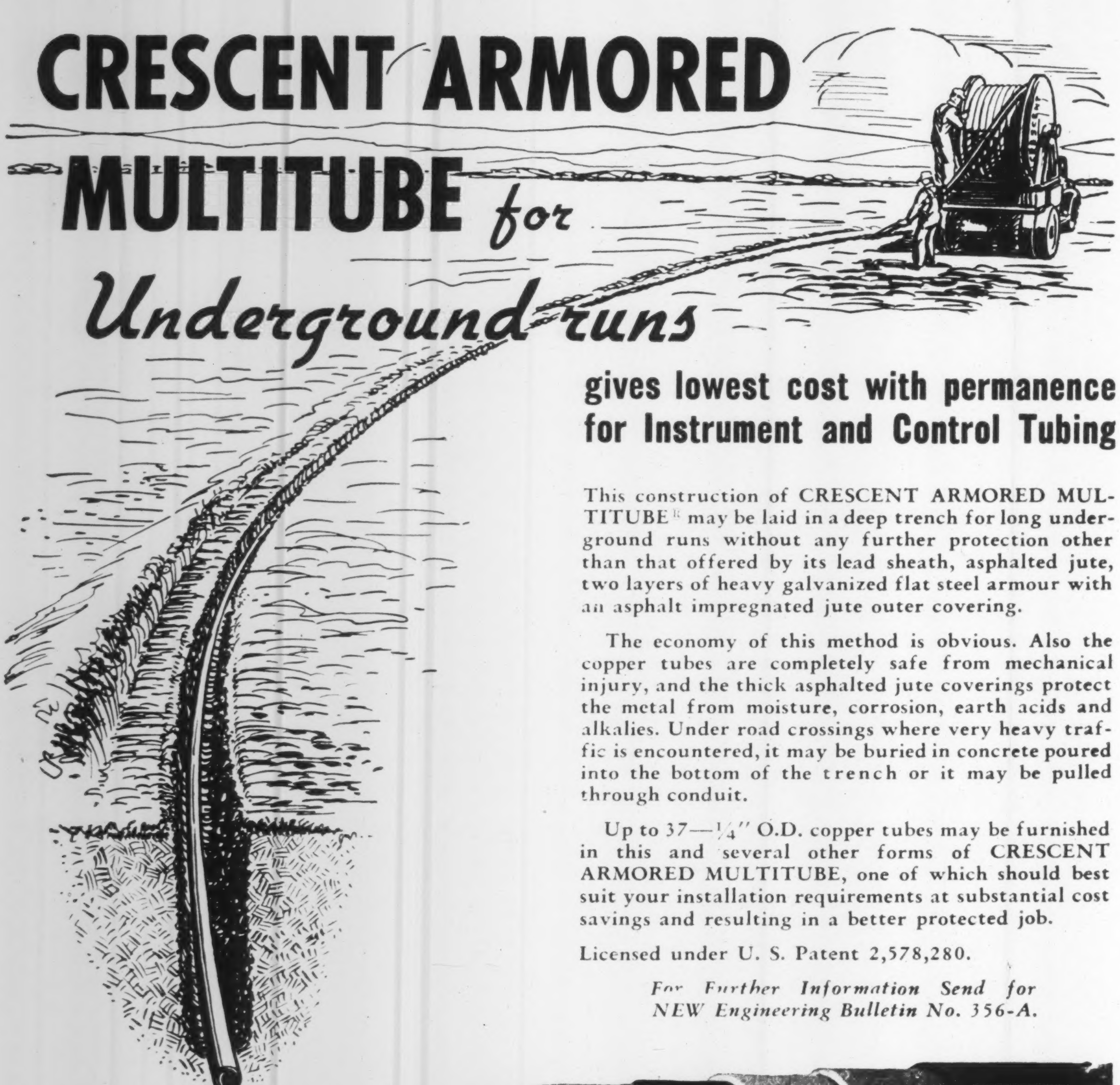
AN "OVER-UNDER" SCALE INDICATING ± VARIATIONS PRECISELY TO 0.02 GRAMS

This unit is just one of the many in the METTLER line of fine balances. Write today for full information.

Mettler
INSTRUMENT CORPORATION
HIGHTSTOWN, N. J.

For more information circle **52** on inquiry card.

CRESCENT ARMORED MULTITUBE *for* *Underground runs*



gives lowest cost with permanence for Instrument and Control Tubing

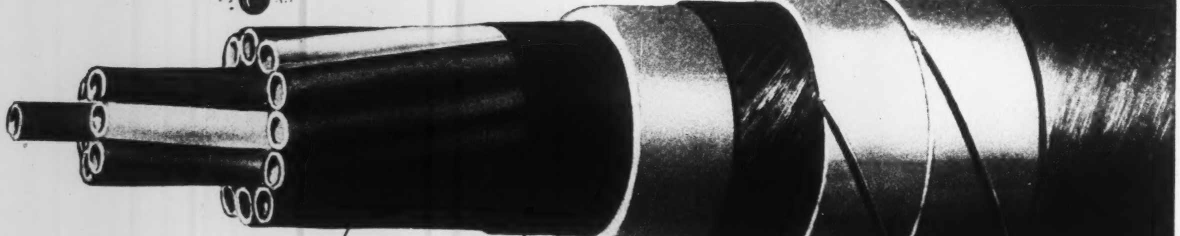
This construction of CRESCENT ARMORED MULTITUBE® may be laid in a deep trench for long underground runs without any further protection other than that offered by its lead sheath, asphalted jute, two layers of heavy galvanized flat steel armour with an asphalt impregnated jute outer covering.

The economy of this method is obvious. Also the copper tubes are completely safe from mechanical injury, and the thick asphalted jute coverings protect the metal from moisture, corrosion, earth acids and alkalies. Under road crossings where very heavy traffic is encountered, it may be buried in concrete poured into the bottom of the trench or it may be pulled through conduit.

Up to 37—¼″ O.D. copper tubes may be furnished in this and several other forms of CRESCENT ARMORED MULTITUBE, one of which should best suit your installation requirements at substantial cost savings and resulting in a better protected job.

Licensed under U. S. Patent 2,578,280.

For Further Information Send for NEW Engineering Bulletin No. 356-A.



CRESCENT INSULATED WIRE AND CABLE CO.

TRENTON, NEW JERSEY

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BOOK Reviews

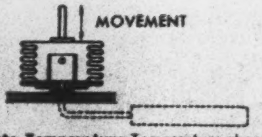
Nichtlineare Regelungsvorgange. edited by Dr. Wolfgang Hahn. R. Oldenbourg Verlag. Rosenheimer Str. 145. Munich. West Germany. [c1956]. 6¼″x9½″. hard cover. 107 p.. DM 11.20. Contains five papers delivered at meeting of Fachausschuss Regelungsmathematik of the Gesellschaft fur angewandte Mathematik und Mechanik (GAMM). Darmstadt. September 8. 1955. dealing with nonlinear regulating systems. Papers are supplemented in this book by discussions and additions.

Punched Cards. Their Application to Science and Industry. edited by Robert S. Casey. James W. Perry. Madeline M. Berry and Allen Kent. Reinhold Publishing Corp.. 430 Park Ave.. New York 22. N. Y. [c 1958]. 697 p. $15. 9¼″. Thoroughly revised and enlarged second edition. Includes hand- and machine-sorted cards. and is intended as elementary instruction manual and advanced handbook. Shows also how to find. arrange. use. store and retrieve information of any kind.

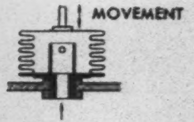
Introduction to Symbolic Logic and its Applications by Rudolf Carnap. revised translation from the German. [c1958] Dover Publications. Inc.. 920 Broadway. New York 10. N. Y.. 241 p.. 5⅜″ x 8″. paperbound. $1.85. Symbolic or mathematical logic. or logistic is the application of symbols in various domains of science (notably in mathematics. physics. and biology) as a means of communication. to express any theory about any objects whatever. The book develops such a "language" and by means of problems. examples and exercises gives the student practice in the techniques of symbolic logic.

Insulation Testing by D-C Methods by E. B. Curdts [c 1958] James J. Biddle Co.. 1316 Arch St.. Phila. 7. Pa.. 43 p.. $2.00 paperbound. 8½″ x 11″. Book describes basic principles. using uncomplicated mathematics. interpretation of tests by the step-voltage method. and test equipment requirements. Contains numerous tabulated test-set selection guides and extensive bibliography.

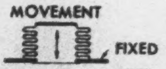
Graphical Symbols for Fluid Power Diagrams. ASA Y32.0-1958 [c 1958.] American Society of Mechanical Engineers. 29 West 39th St.. New York 18. N. Y. 16 p. $1.50.



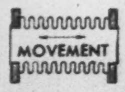
Regulate Temperature Temperature changes cause a thermostatic charge in the bellows to expand and operate a valve, switch, damper, etc. Charge can also be in an external cup.



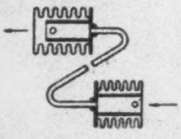
Control Movement Converts pressure effects inside the bellows into controlled movement. Another assembly accomplishes the same job with pressure applied within an external cup.



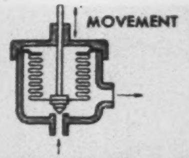
Absorb Expansion Thermal or pressure expansion is absorbed by this assembly. With suitable heads, it can serve as a liquid or gas reservoir, such as an oil reservoir for an electrical cable joint.



Absorb Vibration, Expansion Used as packless, leakless expansion joints to absorb thermal expansion of steam and water lines, and to absorb vibration or provide flexible connections in other applications.



Transmit Motion Thermostatic or mechanical motive force is applied to two Sylphon® bellows assemblies joined by a tube for hydraulic transmission of motion or power.



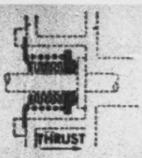
Seal Packless Valves Seamless metal Sylphon® bellows replace packing to form leakproof valves that never need re-packing. Also used to seal stem movement or adjustment.

Cost-Saving

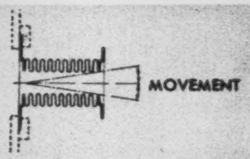
IDEA STARTERS

with

SEAMLESS METAL SYLPHON® BELLOWS



Seal Shafts Spring pressure holds nose of seal against shoulder on shaft. Used for refrigerator compressors, etc., to prevent leakage around revolving shaft. Another type rotates with shaft and seals against stationary plate.



Seal Flexible Joints Used to seal a flexible joint or mechanical movement of levers, linkage, etc., against leakage where the movement must be conveyed outside an enclosure, such as operating stem of float switches.

Fulton Sylphon Bellows Assemblies

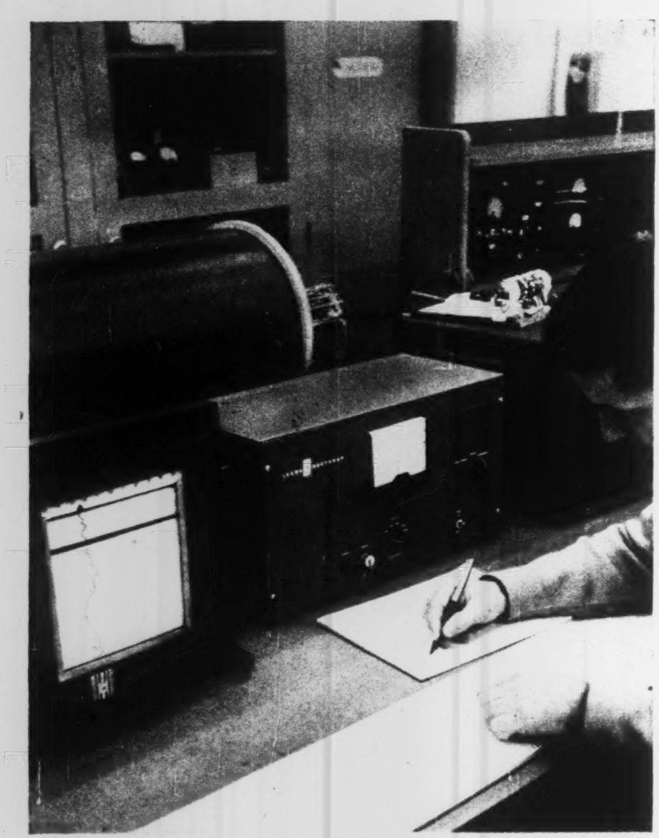
Does one of these bellows applications spark an idea for improved design or cost reduction for your product? Your application idea combined with our half-century of experience in making custom-engineered bellows assemblies may lead to tangible benefits for your company. Write for Engineering Service or Catalog XL-1400.

Mr Controls

Robertshaw-Fulton CONTROLS COMPANY

FULTON SYLPHON DIVISION • Knoxville 1, Tennessee

For more information circle 54 on Inquiry card.



SPEEDOMAX® H

...the key to highly dependable tests at AMP Incorporated's research lab

Investigation of thermals generated by terminals under high ambient temperatures is one application of Speedomax H instruments in the research laboratories of Aircraft-Marine Products, Inc., Harrisburg, Pa. A Speedomax H Recorder, out of view to the right of the operator, records the 1000 F temperature of the furnace in which the terminals are being heated. An L&N Stabilized Preamplifier with a Speedomax H zero-center millivolt recorder plots the thermals generated by these terminals. Continuous operation without instrument failure (the average test runs about 240 hours) and reproducibility of tests within 1 μv are two advantages of this equipment.

In this same laboratory where new and improved products are being developed and tested to supplement AMP's wide variety of terminals, connectors, plugs, etc., for the electronic, aircraft and other industries, a Speedomax H 2-action D.A.T. Controller is used. This instrument precisely regulates the temperature of an electric batch-type furnace to within ±2 F. The flexibility of this control helps them meet a variety of test conditions in investigating the effects of heat on various connector insulation materials. The instrument's manual rate of approach dial brings the test material up to working temperature in the shortest possible time without overshoot. It also permits rapid recovery of the test temperature when the sample or the control point is changed.

In many research applications where temperatures, pH, voltage, speed, etc., are being studied, a Speedomax H Recorder or Controller can fill your requirements for a high quality instrument that saves bench space, is low in cost and is available for quick delivery (two to four weeks after order is received). For more information, write to Leeds & Northrup Co., 4955 Stenton Ave., Phila. 44, Pa., for Data Sheets ND46-33(100-106).

LEEDS NORTHRUP
Instruments Automatic Controls • Furnaces

For more information circle **55** on inquiry card.

editorial

INSTRUMENTATION 1958

A STATE-of-the-art survey of any field should have perspective. It should report the new developments, but it should also interpret them in the light of existing techniques in general practice. This is a most difficult task, seldom realized.

Electronic Control

Much publicity has been given to the threefold increased in 1958 in general-purpose electronic process-control systems (from two to six lines). There is little basic significance in this.

As the market for electronic controllers showed no evidence of any expansion by a factor of three (or even two) in 1958, these new lines mean strongly increased competition for the electronic market (not always a constructive development). More happily, it could put an end to the fruitless pneumatic versus electronic debates of the past. Perhaps now we shall see more quantitative studies such as analog-computer simulations, which could conceivably prove economies (resulting from the response speed of electronic systems) of a magnitude sufficient to expand the electronic process control market significantly.

This leads, directly, to one aspect of instrumentation wherein significant things did happen during the year. This is "systems engineering."

Systems Engineering

As readers of *I&A* throughout the year know, we devoted considerable editorial emphasis to debunking exaggerated systems claims. Many newer publications in this field made claims that were so misleading and out-of-touch with reality that an entire issue of *I&A* was devoted to an attempt to place the systems concept in perspective. However, many established firms made large investments in anticipation of an explosive systems market that did not materialize in 1958. Most systems firms and systems divisions are only now obtaining projects: it was of this that we warned the industry while we reported the techniques for optimum systems design and optimum control.

The computer (analog or digital) has possible application in three ways—(1) design, (2) operations, such as linear programming, or (3) control, as in optimum control. It was the implications of the latter use that caused the rash of systems speculation (and expenditures) in 1958—but it will be at least several years before this phase of instrumentation can prove its economic justification. As even a small computer-in-control situation requires an expenditure of $100,000 or more, economic justification must precede, not follow, the growth of this market.

The significant development of 1958 in this field was that systems divisions and firms found an appreciable number of industrial firms willing and able to enter into coöperative study projects associated with control computers. Thus there are now to our knowledge at least 18 industrial processes and operations being carefully investigated and prepared for computer-control analysis. These processes are in many different industries—petrochemical, iron and steel, cement manufacturing, power generation. Many are publicized: others are proceeding under wraps.

These projects must be considered study projects—the main products will be logged data. The unique feature is that the data will include operating guides to indicate process efficiency. For example, in one project, 160 process variables are used to compute 27 operating guides (catalyst circulation rate, carbon burning rate, material balance, etc.)

Just what the eventual significance of these data may mean in all the projects under way will not be established with finality for one to three years. The projects are being closely watched by your editors: an attempt to interpret the early results will be made near the end of 1959.

Analog Computers

Industrial uses of analog computers also increased significantly in 1958—but mostly by computer services. Sales of analog computers to industry did not reach anticipated size.

This is doubly unfortunate. Only the analog computer can establish the many inter-relationships of variables which should be known even before digital control becomes practical. The latter occurs only *after* the relationships are known. Today many of these are assumed: this uncertainty could be reduced by greater

ISSUES

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and thereby registers the end of thirty-one years of *Instruments and Automation's* service to users of measurement and control devices—service to THE UNITED STATES OF AMERICA

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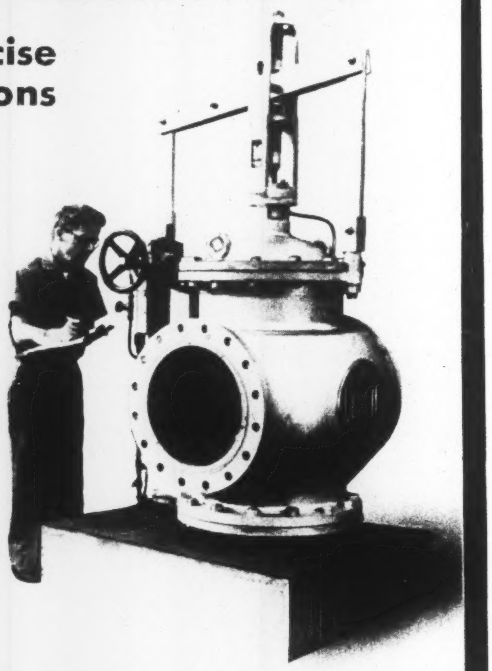
A complete line for precise power applications



Leslie Co. offers a wide range of single seated valves in sizes ½″ to 16″ and double seated control valves. In addition, there are many new standard valves designed specifically for power industry applications in both sub-critical and super-critical power generating stations. Valves are available with these power service features:

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Leslie control valves are designed to handle hot and flashing condensate . . . temperatures to 1150°F per ASA rating. They are providing reliable service under extremely severe operating conditions in a variety of central station applications such as:

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You may choose from a variety of sizes and diaphragm actuators to accommodate almost any operating air supply up to 100 psi. In addition, electro-mechanical, pneumatic cylinder and electro-hydraulic actuators can be supplied.

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TRADE LESLIE MARK

REGULATORS and CONTROLLERS

LESLIE CO., 299 Grant Avenue, Lyndhurst, New Jersey

EDITORIAL—CONTINUED

use of the analog computer as we have "preached" for four years.

Inasmuch as this knowledge of inter-relationships of variables is a prerequisite to computer control, and inasmuch as the implications of computer control have led industry into an expenditure of several millions of dollars, we make the following suggestion for 1959: A *combined* and cooperative analog-computer digital-logger-controller-computer study could be achieved at a cost not much more than the cost of either alone and the results may well show that only the use of combined techniques makes either one economic. Obviously, deep analysis of any problem should involve the best of analog (simulation) *and* digital (logging-computing) techniques. It is interesting to note that there are three firms emphasizing industrial computer-control, and three general-purpose analog-computer firms emphasizing industrial simulation. We suggest that three important partnership arrangements are in order. We predict that such partnerships would be immensely fruitful to both partners, to industry in general, and to the instrument industry.

As 1958 ends, we welcome a new analog-computer firm to the nation—Electro Precision Corporation of Arkansas, marketing a "Collegiate" analog computer. We hope, for the sake of our nation's educational state, that many of these find their way into American colleges and universities.

This leads us to the subject of education in 1958.

Education

A false and dangerous theory found wide acceptance in technical circles in 1958. Editors, civic leaders, commentators, committee chairmen and, worst of all, university academic groups, all found themselves agreeing with a proposition that is not only not true but actually harmful to the nation and to the instrument industry in particular. This is the "logical" premise that education should be *either* highly theoretical *or* highly vocational; that the theoretical and academic curriculum should use little or no equipments or hardware, and that such hardware should be reserved for the vocational and technician levels.

This "or" concept, so widely believed, is a threat to the instrument industry, to education, and to the nation. As far as the instrument industry is concerned, it means that instruments would not be used in high schools or in any academic curricula; as far as education is concerned it means that the great motivation appeal of modern instrumentation would not be used to capture students and guide them into science; as far as the nation is concerned it means that academic students will receive deadeningly dull theoretical subjects with little relation to the actual physical world, and that engineers and scientists will graduate from college with little knowledge of modern instrumentation. Nor is this exaggeration; it already has occurred to an alarming degree.

The entire "OR" concept is false. A good curriculum should contain the *optimum* amounts of theory "AND" hardware to achieve the desired educational objective, be it academic or vocational. Yet the "OR" concept is so widely held that we have on record some leading electronics authors saying that *electronics* should not be taught in the high school; we even have the Foundation for Instrument Education and Research saying that *Instrumentation* should not be taught in the high school!

This subject is of such importance that it will be treated in detail in our next issue.

Nucleonics

With 38,000 scientists and engineers already employed in nuclear work, universities are emphasizing reactor education. A nuclear package complete with subcritical reactor was placed on the market in 1958 at a price of $30,000. The market for reactor simulators also is promising.

Highlight of the year in the field of nucleonics was the Second United Nations Conference in the Peaceful Uses of Atomic Energy, held in Geneva in September, 1958. It was attended by 5000 delegates and observers from 67 countries, and 2300 papers were presented, probably the largest scientific gathering ever held.

The vast number of papers on this subject alone (nucleonics) emphasizes the growing importance of another field of technical activity which falls into the "instrumentation" category.

Information Retrieval

This is information retrieval—the abstracting, classifying, sorting, filing and retrieving of information contained in reports, books, manuscripts and articles—and in many languages. There are more than 1500 different scientific and technical professional groups and societies in USA and Canada. As many as 2000 papers are produced in one year by one society, and the cross-interest in technical work means that all fields need be monitored by all others. Information processing, which will be the subject of an International Conference in Paris, June 15-20, 1959, is a field to watch in 1959.

The Market in 1959

It is fashionable to predict a healthy and expanding economy, complete with increased productivity due to greater use of instrumentation. But anybody who closes his eyes to the dark clouds on the horizon is indulging in wishful thinking, a fairly common habit today.

There are still more than 4 million unemployed in the USA; military expenditures are admitted to be both an economic crutch and a military necessity (leaving humanity with the unconscious choice between depression and nuclear war); industrial productivity increase has fallen to the low figure of 1% (by some reports); the education problem deepens every month, and not only technologically. These are the types of problems, some of which today appear almost unsolvable, that will determine whether the nation—and our industry—remains healthy in 1959. Who then can predict a happy or prosperous future without discussion of these problems? Not even a population increase can be predicted safely today. **MHA**

← Circle 56 on inquiry card.

Soviet Trends in Computers for Control of

A clear and thorough résumé of the state of Soviet computer art, including general-purpose and special-purpose analog computers, network analogs, "programmed and reflection" process control computers, and optimum parameter control computers. Last month this report discussed Soviet computers for operations research and simulation studies. The report continues with a description of a special-purpose computer.

Group II—Computer Devices for the Computation of Complex Parameters

Manufacturing processes can be characterized by certain parameters to be used as control information. In most cases those parameters are ordinary values representing the process from one aspect only. Usually, however, a single parameter is not sufficient for controlling the process as a whole. Therefore, there arises the necessity of obtaining certain complex, integral or statistical parameters that give a more complete representation of the process.

Such complex parameters are typical for the control of processes which either proceed at faster rates or are of a complex structure involving many interdependent parameters. In blast furnace controls for example, Prof. Sorokin, from the Donetz Industrial Institute, considers such complex variables as the effective capacity (the specific consumption of carbon in kg per ton of cast iron) and the blast furnace output (tons per minute).

For obtaining these two complex parameters it is necessary to continuously solve two nonlinear relations containing several variable parameters received from instruments installed on the blast furnace.

Examples of the use of complex process data may be cited from different branches of technique—chemistry, metallurgy, oil refining, etc. Similar problems are encountered in determination of operation conditions of routines for any given process or plant, using initial process data.

Cutting Ratings Computer

An example of a computer for operational routines is the general-purpose cuttings rating computer used for determination of optimal cutting conditions for most widely used machining operations—turning, milling, and drilling. This computer (Fig. 6) can be applied also in technical rating and for research work in laboratories dealing with cutting processes.

The computer circuit is constructed on the principle that all of the formulas used for determining the cutting operational conditions (Fig. 8) can be brought to the transcendental form:

$$a_1^{b_1}\, a_2^{b_2}\, a_3^{b_3} \ldots\ldots\ldots\ldots\ a_n^{b_n} = 1$$

where a_i and b_i are actual values. The unknown may be any of the values a_i or b_i. Values b_i may be positive or negative, while value a_i may be positive only.

The tubeless circuit of the computer (Fig. 7) is designed on the compensation principle. All the potentiometers (on which the desired values and the value to be sought are preset) are connected, through resistors, with a common null galvanometer in which all currents flowing across the resistors are summed. When the galvanometer pointer is set at zero, the graduated scale on the front panel gives the required values with an accuracy sufficient for practical needs (the instrument error not exceeding several per cent). For simplification, the computer does not solve the formulas given in the Table of Fig. 8 but, rather, the logarithms of the relations. However, the readings of the variables are finally obtained in natural values calibrated on the scales of the computer knobs.

The computer is designed mainly for data concerning the working of structural carbon and alloy steels (including heat-resisting steels), and gray and malleable cast iron, when using tools made of hard alloy and steel. Up to 23 different variables (such as work diameter, cutting speed, admissible feed, spindle number of revolutions, depth of cutting, number of cutter strokes, machine time, motor capacity, and others) can be inserted into the computer. Taking several of these values for a base, it is possible, referring to the formulas given in Fig. 8, to rapidly compute the parameter which is dependent on these values.

Prof. Pankin supports the view that optimum operational routines can double the average output in machine time against values recommended in handbooks.

In addition to routine decision making, the computer also permits choosing the most appropriate type of machine-tool, cutter, and mode of fixation.

Manufacturing Processes

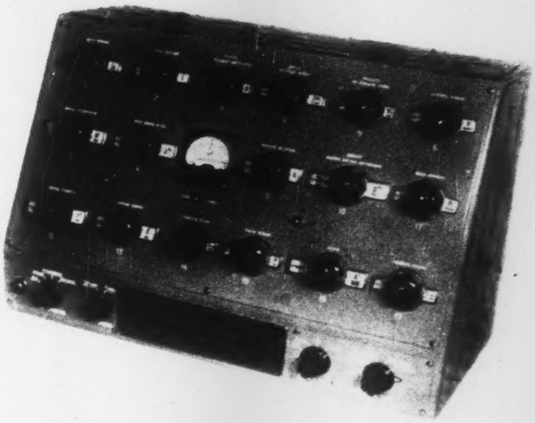


FIG. 6. COMPUTER type BPRR-2.

V. B. USHAKOV
Scientist, Moscow University

The time required for routine decision making is reduced to approximately 2 or 3 minutes. The computer can be operated from a 220-v, 127-v or 36-v single-phase line. Its weight does not exceed 25 kg.

Note that the values are inserted manually into the cuttings ratings computer by the operator; computers for the determination of complex process data can receive input automatically from sensers connected to the controllable process.

Group III—Computers for Training of Process Operators

This class of computing machines includes complex simulators for training crews for aeroplanes and operators of atomic power stations, high-speed rolling mills, etc. Such computers, simulating the dynamics of the process are rather complicated and similar in design to computers of the first group, their distinguishing feature being that they usually operate in real time and include the operators being trained.

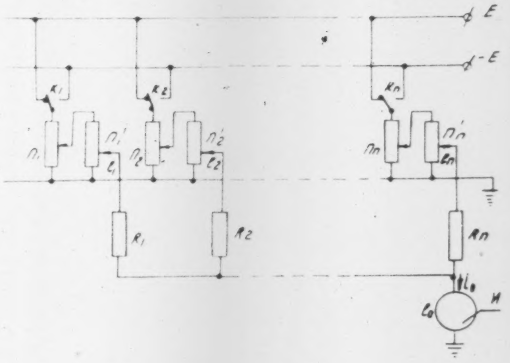
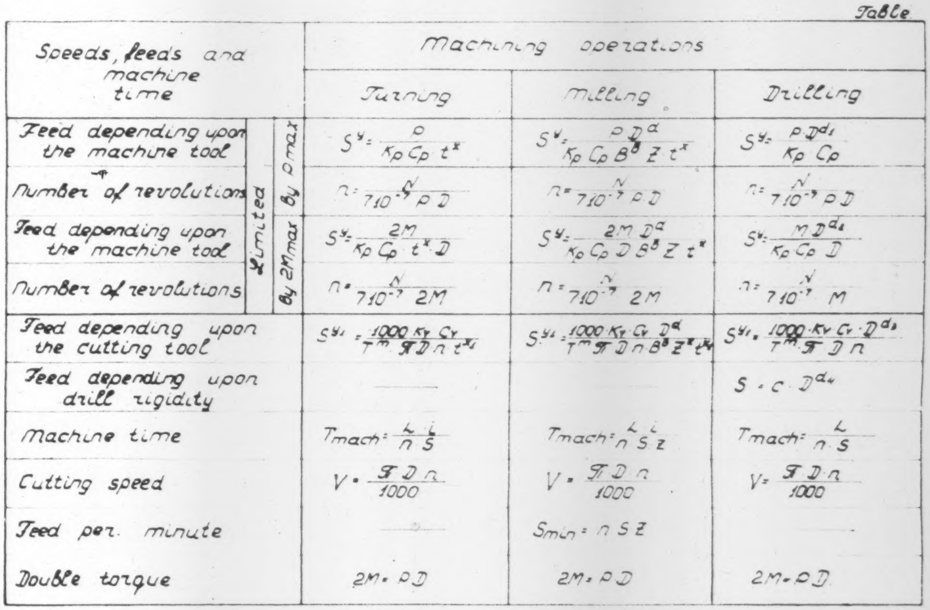


FIG. 7. SCHEMATIC circuit of computer type BPRR-2.

Next month this report continues with computers for automatic process control.



Table

Speeds, feeds and machine time			Machining operations		
			Turning	Milling	Drilling
Feed depending upon the machine tool	Limited	By P max	$S^{y} = \frac{P}{K_p C_p t^x}$	$S^{y} = \frac{P D^{a}}{K_p C_p B^{b} Z t^{x}}$	$S^{y} = \frac{P D^{d_1}}{K_p C_p}$
Number of revolutions			$n = \frac{N}{710^{-7} P D}$	$n = \frac{N}{710^{-7} P D}$	$n = \frac{N}{710^{-7} P D}$
Feed depending upon the machine tool		By 2M max	$S^{y} = \frac{2M}{K_p C_p t^{x} D}$	$S^{y} = \frac{2M D^{a}}{K_p C_p D B^{b} Z t^{x}}$	$S^{y} = \frac{M D^{d_1}}{K_p C_p D}$
Number of revolutions			$n = \frac{N}{710^{-7}\, 2M}$	$n = \frac{N}{710^{-7}\, 2M}$	$n = \frac{N}{710^{-7}\, M}$
Feed depending upon the cutting tool			$S^{y_1} = \frac{1000 K_v C_v}{T^{m} \pi D n t^{x_1}}$	$S^{y_1} = \frac{1000 K_v C_v D^{a}}{T^{m} \pi D n B^{b} Z^{x} t^{x_1}}$	$S^{y_1} = \frac{1000 K_v C_v D^{d_1}}{T^{m} \pi D n}$
Feed depending upon drill rigidity			—	—	$S = C D^{d_4}$
Machine time			$T_{mach} = \frac{L\, i}{n S}$	$T_{mach} = \frac{L\, i}{n S z}$	$T_{mach} = \frac{L}{n S}$
Cutting speed			$V = \frac{\pi D n}{1000}$	$V = \frac{\pi D n}{1000}$	$V = \frac{\pi D n}{1000}$
Feed per minute			—	$S_{min} = n S Z$	—
Double torque			$2M = P D$	$2M = P D$	$2M = P D$

FIG. 8. TABLE of formulas for calculating operational routines for optimum cutting.

Terms and Definitions for the Weighing Industry

ANALYTICAL BALANCE, n. An equal-arm balance characterized by great sensitiveness (small SR) and small capacity (rarely exceeding 200 grams), and usually provided with an auxiliary device to permit readily of the designed or purported refinement of weighing.

APOTHECARIES' SYSTEM, n. The system of units formerly in universal use in the United States of America and England for weighing and measuring drugs and compounding prescriptions. (1) The system of mass units includes the ounce of 8 drams, the dram being divided into 3 scruples of 20 grains each. (2) The system of volume units includes the fluid ounce of 8 fluid drams, the fluid dram being divided into 60 minims.

ASSAY BALANCE, n. A very sensitive balance, usually equal arm and of one gram capacity, especially adapted for use in assaying.

AVOIRDUPOIS SYSTEM, n. The system of mass units in common use in English-speaking countries for weighing commercially all commodities except precious stones, precious metals, and drugs. Its fundamental unit is the pound of 7000 grains, and divided into 16 ounces of 437.5 grains each. The avoirdupois pound is equal to 453.5924277 grams.

BALANCE, n. (1) An instrument for weighing; in its simplest form, an equal-arm weighbeam with suspended pans.

BIFURCATED, adj. Divided into two branches.

BUOYANCY, n. The upward pressure exerted upon an immersed or floating body by the fluid (air, water, etc.) which surrounds it; a factor in precision weighing. See Weight (1).

CARAT, n. A unit of mass for precious stones, especially diamonds and pearls, equal to 200 milligrams; originally known as the International Metric Carat, and sometimes now referred to as the Metric Carat.

COUNTERPOISE WEIGHT, n. An adjusted, removable, (usually) slotted weight, intended to counterpoise an applied load of designated weight value. Sometimes also colloquially called Counterweight. Cf. Bottle Weight, Counterbalance Weight, Hanger Weight.

CREEP, n. With respect to certain types of springs, additional deformation without increase in applied load, as a result of leaving the load applied for a substantial length of time. Cf. Hysteresis.

DYNAMOMETER, n. An apparatus for measuring force or power, such as the brake horsepower of a steam or internal combustion engine or of an electric motor, or the drawbar pull of a locomotive.

GRAIN, n. (1) A unit of mass common to the avoirdupois, troy and apothecaries' systems, equal to 1/7000 of an avoirdupois pound, or 1/5760 of troy or apothecaries' pound, or 64.7989 milligrams. (2) The unhusked or threshed seeds or fruits of various food plants.

GRAM, n. The fundamental unit of mass in the Metric System: 0.001 of the mass of the International Prototype Kilogram. The basic relation between mass units of the Customary and Metric Systems is: one pound avoirdupois = 453.5924277 grams. The gram is equal to 1000 milligrams, or 15.4324 grains.

GRAVITY, n. The accelerating tendency of bodies toward the center of the earth. Its symbol is "g", and its value, which varies from place to place, is about 980 cm (or 32.16 ft) per second per second.

GROSS TON, n. A Long ton.

INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES, n. A scientific bureau maintained at Sevres, France, through the cooperation of some 33 countries, including the United States of America. This bureau maintains the international standards of length and mass, and periodically compares and certifies National Standards submitted for that purpose.

INTERNATIONAL PROTOTYPE KILOGRAM, n. The cylinder of platinum-iridium deposited at the International Bureau of Weights and Measures and declared to be the international prototype of the kilogram by the First General Conference on Weights and Measures. This is the fundamental Standard from which all metric standards of mass are derived. Cf. Kilogram, National Prototype Kilogram No. 20.

Prepared by the Terminology Committee of the Scale Manufacturers Association, Inc., One Thomas Circle, Washington 5, D. C.

Abstracted from book of same title, price $1.00.

INTERNATIONAL PROTOTYPE METER, n. The bar of platinum-iridium deposited at the International Bureau of Weights and Measures and declared to be the international prototype of the meter by the First General Conference on Weights and Measures. This is the fundamental Standard from which all metric standards of lengths are derived. Cf Meter, National Prototype Meter No. 27.

METRIC TON, n. 1000 kilograms.

METROLOGY, n. The science of weights and measures.

MOTION WEIGHING, n. The weighing of loads without causing them to come to a stop on the load receiving element of a scale.

NATIONAL CONFERENCE ON WEIGHTS AND MEASURES, n. An organization of weights and measures officials of the United States which meets annually at the National Bureau of Standards, Washington, D. C.

NATIONAL SCALE MEN'S ASSOCIATION, n. An organization of persons interested in the design, manufacture, installation, maintenance, testing and operation of weighing equipment in the United States and Canada.

OUNCE, n. Either of two different units of mass, one in the Avoirdupois system and one common to the Troy and Apothecaries' Systems. (1) the Avoirdupois Ounce is equal to 1/16 avoirdupois pound or 437.5 grains, or 28.3495 grams. (2) The Troy or Apothecaries' Ounce is equal to 1/12 troy or apothecaries' pound or 480 grains, or 31.1035 grams. (The ounce is also a unit of capacity in the customary and apothecaries' systems of fluid measure.)

PERCENTAGE SCALE, n. An unequal-arm scale, especially designed for indicating in percent the loss in weight of a sample after cleaning, drying etc.; sometimes also equipped to indicate the weight per bushel of grain, of which a sample of specified volume is the applied load. Sometimes also called Moisture Percentage Scale. Cf. Grain Tester.

POISE, n. A weighbeam element, adjusted as to its weight, movable parallel to the longitudinal axis of the weighbeam, whose position with reference to the graduations on the bar with which it is associated, or with reference to a fixed index, constitutes the weight indication. Sometimes colloquially called Pea. Cf. Turnover Poise.

POUND, n. Either of two different units of mass, one in the Avoirdupois System and one common to the Troy and Apothecaries' Systems. (1) The Avoirdupois Pound is equal to 7000 grains, or 453.5924277 grams, and is divided into 16 ounces. (2) The Troy or Apothecaries' Pound (rarely used) is equal to 5760 grains, or 373.242 grams, and is divided into 12 ounces.

PRESCRIPTION SCALE OR PRESCRIPTION BALANCE, n. A Scale, usually an equal-arm scale of small capacity, especially designed or adapted for the weighing of ingredients of medicinal and other formulas prescribed by physicians and others and entering into the ordinary trade of pharmacists and chemists. Prescription scales identified as Class A or Class B, according to their accuracy and sensitiveness.

PROVING LEVER, n. One of (usually) a pair of levers of the first class especially designed or adapted for use with a complement of standard weights to apply known force or load to the weighing table of a testing machine.

PROVING RING, n. An elastic ring, suitable for calibrating a testing machine, in which the deformation of the ring under diametral load is measured by means of a micrometer screw and a vibrating reed mounted diametrically in the ring.

SENSIBILITY RECIPROCAL (SR), n. The change in applied load required to change the position of equilibrium of a weighbeam or indicator a definite amount; in a scale equipped with a weighbeam and trig loop without over-and-under device, the change in applied load required to change the position of equilibrium of the weighbeam from the midpoint of its travel to either limit thereof. The term has no application in the case of an automatic indicating scale.

SPRING SCALE, n. A scale in which the applied load is counter-poised, either directly or indirectly through a lever train, by a counter force induced axially in a helical spring, whose extension is translated by suitable means into an indication of weight value. Sometimes also colloquially called Spring Balance.

STANDARD WEIGHT, n. A weight expressly designed and constructed for testing weights of lower classes and sometimes also used in weighing operations demanding relatively high precision.

TARE, n. The weight of an empty container or vehicle, or of spools, cores or wrappings, or the allowance or deduction from gross weight made on account thereof.

WEIGHBEAM, n. In a scale of other than the automatic indicating or automatic recording types, that element whose angular position denotes the balance condition. In a more restricted sense, the device or assembly upon which, by the manipulation of poises and or counterpoise weights, the applied load is counterpoised and its weight value indicated. Sometimes also colloquially called Beam.

WEIGHT

A survey of weighing techniques, including the various types of weight, spring, current, buoyancy and load-cell equipments.

M. H. ARONSON

WEIGHT is the force with which a mass is attracted toward the center of the earth by gravity. It is measured by applying an opposing force of known magnitude, which balances the unknown force (weight). Its importance in measurement cannot be overestimated—all measurements refer ultimately to the three fundamental measurements of length, time, and mass. The conversion factors for units of mass are given in Table 1.

There are six basic methods for weight measurement—that is, six basic types of opposing forces: (1) a known *weight*, (2) a *pneumatic* force, (3) *spring* force, (4) *bouyancy* force, (5) magnetic force due to *current*, and (6) reaction of an elastic solid, hydraulic or pneumatic *load cell*.

Weight Balances

The use of a known weight as the opposing force is perhaps the most accurate of all quantitative measurements because the force due to weight is determined directly by the invariable force of gravity. Weights are used in several different types of balances and scales, usually being compared on opposite side of a *weighbeam*.

Beam Balance Fundamentals

A few fundamental factors about levers and beam systems should be kept in mind when selecting or operating weight-balance systems. One is the relation between center-of-gravity of the system and sensitivity of the balance.

TABLE 1—CONVERSION FACTORS FOR UNITS OF MASS

Values in boldface are exact values

Units of mass less than pounds and kilograms

Unit	Grains	Apothecaries' scruples	Pennyweights	Avoirdupois drams	Apothecaries' drams	Avoirdupois ounces
1 grain =	**1**	**0.05**	0.041 666 67	0.036 571 43	0.016 666 7	0.002 285 71
1 apothecary scruple =	**20**	**1**	0.833 333 3	0.731 428 6	0.333 333	0.045 714 3
1 pennyweight =	**24**	**1.2**	**1**	0.877 714 3	**0.4**	0.054 857 1
1 avoirdupois dram =	**27.343 75**	**1.367 187 5**	1.139 323	**1**	0.455 729 2	**0.062 5**
1 apothecary dram =	**60**	**3**	**2.5**	2.194 286	**1**	0.137 142 9
1 avoirdupois ounce =	**437.5**	**21.875**	18.229 17	**16**	7.291 67	**1**
1 apothecary or troy ounce =	**480**	**24**	**20**	17.554 28	**8**	1.097 142 9
1 apothecary or troy pound =	**5 760**	**288**	**240**	210.651 4	**96**	13.165 714
1 avoirdupois pound =	**7 000**	**350**	291.666 7	**256**	116.666 7	**16**
1 milligram =	0.015 432 356	0.000 771 618	0.000 643 014 8	0.000 564 383 3	0.000 257 205 9	0.000 035 273 96
1 gram =	15.432 356	0.771 618	0.643 014 85	0.564 383 3	0.257 205 9	0.035 273 96
1 kilogram =	15 432.356	771.617 8	643.014 85	564.383 32	257.205 94	35.273 96

Unit	Apothecaries' or troy ounces	Apothecaries' or troy pounds	Avoirdupois pounds	Milligrams	Grams	Kilograms
1 grain =	0.002 083 33	0.000 173 611 1	0.000 142 857 1	64.798 918	0.064 798 918	0.000 064 798 9
1 apothecary scruple =	0.041 666 7	0.003 472 222	0.002 857 143	1 295.978 4	1.295 978 4	0.001 295 978
1 pennyweight =	**0.05**	0.004 166 667	0.003 428 571	1 555.174 0	1.555 174 0	0.001 555 174
1 avoirdupois dram =	0.056 966 146	0.004 747 178 8	**0.003 906 25**	1 771.845 4	1.771 845 4	0.001 771 845
1 apothecary dram =	**0.125**	0.010 416 667	0.008 571 429	3 887.935 1	3.887 935 1	0.003 887 935
1 avoirdupois ounce =	0.911 458 3	0.075 954 861	**0.062 5**	28 349.527	28.349 527	0.028 349 53
1 apothecary or troy ounce =	**1**	0.083 333 33	0.068 571 43	31 103.481	31.103 481	0.031 103 48
1 apothecary or troy pound =	**12**	**1**	0.822 857 1	373 241.77	373.241 77	0.373 241 77
1 avoirdupois pound =	14.583 333	1.215 277 8	**1**	**453 592.427 7**	**453.592 427 7**	**0.453 592 427 7**
1 milligram =	0.000 032 150 74	0.000 002 679 23	0.000 002 204 62	**1**	**0.001**	**0.000 001**
1 gram =	0.032 150 74	0.002 679 23	0.002 204 62	**1 000**	**1**	**0.001**
1 kilogram =	32.150 742	2.679 228 5	2.204 622 341	**1 000 000**	**1 000**	**1**

Units of mass greater than avoirdupois ounces

Units	Avoirdupois ounces	Avoirdupois pounds	Short hundredweights	Short tons	Long tons	Kilograms	Metric tons
1 avoirdupois ounce =	**1**	**0.062 5**	**0.000 625**	**0.000 031 25**	0.000 027 901 79	0.028 349 53	0.000 028 349 53
1 avoirdupois pound =	**16**	**1**	**0.01**	**0.000 5**	0.000 446 428 6	**0.453 592 427 7**	0.000 453 592 43
1 short hundredweight =	**1 600**	**100**	**1**	**0.05**	0.044 642 86	45.359 243	0.045 359 243
1 short ton =	**32 000**	**2 000**	**20**	**1**	0.892 857 1	907.184 86	0.907 184 86
1 long ton =	**35 840**	**2 240**	**22.4**	**1.12**	**1**	1 016.047 04	1.016 047 04
1 kilogram =	35.273 957	2.204 622 34	0.022 046 223	0.001 102 311 2	0.000 984 206 4	**1**	**0.001**
1 metric ton =	35 273.957	2 204.622 34	22.046 223	1.102 311 2	0.984 206 40	**1 000**	**1**

The weighbeam has a fulcrum. The imaginary line, parallel to the beam, which passes through the fulcrum is often called a "range line." If the center of gravity of the weighing system is below this range line, any motion of the beam causes a pendulum-type restoring force, and the beam seeks a stable equilibrium point. The system is thus *stable* and *seeking*—that it, it seeks an equilibrium point. Analytical balances are stable and seeking, and usually have a means either for raising the center of gravity to increase the sensitivity or lowering it to reduce the sensitivity.

If the center of gravity of the system is above the range line, any deviation of the beam from equilibrium causes the system to go further out of balance; the system is unstable and goes out of balance in an accelerated manner. It is sometimes referred to as an *acceleration* balance.

If the center of gravity is on the range line, the balance has a theoretically infinite sensitivity, limited of course by friction in the pivot. It also has an important feature—it is insensitive to orientation and need not be level. This fact is used in some industrial scales, as will be shown. As the system has no restoring force, it is called a *dead system*, and requires some other means to effect a balance, such as a spring or torsion element.

Balance Sensitivity

The term "sensibility reciprocal" is used to define balance sensitivity. SR is the amount of weight that will cause a "noticeable" deflection of the weighbeam. As the term "noticeable" is vague, it is suggested that SR be the weight that will cause a deflection of 1/10″ (or some precise amount, such as 1 mm) of the final indicator. (It appears from the literature that some manufacturers now employ this definition of SR. Others use a "1-division" change in rest point, but with no agreement on the division size.)

TABLE 2—NBS WEIGHT CLASSIFICATIONS

Classification	Application
Precision Laboratory Standards	
Class J	Microweight standards (microbalance work).
Class M	High-precision scientific standards (reference, high-precision, and high-constancy work).
Class S	Scientific standards (reference, calibration, and precision analytical work).
Class S-1	Laboratory standards (routine analytical and precision nonmetric work).
Laboratory Weigths	
Class P	Analytical and precise technical weights.
Class Q	General laboratory, technical, and student weights.
Class T	Utility weights.
Commercial Standards	
Class A	State primary standards.
Class B	State working standards.
Class C	Test weights.
Trade Weights	Used in scale of commodities. Classes are listed in NBS Handbook 44.

The 1/10″ deflection requirement continues to be valid when beam deflection is sensed by an LVDT and output is connected to an indicator or recorder. The SR would then be the amount of weight that will cause 1/10″ movement of the final display (pointer or pen).

Weight Tolerances

The precision of a weight balance depends on the tolerances of the set of weights used.

Allowable weight tolerances are established by the National Bureau of Standards (Circular 547, Section 1). The heavier weights have tolerances that are a percentage of the weight. The lighter weights have fixed tolerances, the most accurate (Class M) having an individual tolerance of 0.0054 mg.

Sensitivity Classification

Weight balances fall into four basic sensitivity classes—(1) *microbalances*, including high-sensitivity analytical balances, whose sensitivity is expressed in micrograms/division, (2) *milligram balances*, including most analytical balances, whose sensitivity is expressed in milligrams/division, (3) *gram balances*, whose sensitivity is expressed in grams/division, and (4) *ounce* and *pound* balances, including most industrial scales, whose sensitivity is expressed in ounces or pounds/division.

The microbalance achieves its sensitivity by use of precision elements such as sapphire knife edges and planes to reduce friction and by having the center of gravity very close to the range line. Effects of static electricity are minimized by use of metallized conducting glass and by grounding of all metallic elements via a binding post on the balance.

Application Classification

Weight balances also are commonly classified according to use—for example, analytical balances, assay balances, prescription balances, and many others.

Types of Weight Balances

In many balances the weights are compared at opposite ends of an *equal-arm weighbeam* (Figs. 1, 2, 4). In many scales the known weight can be given a variable moment by use of *unequal-arm weighbeams* or sliding weights (the term "scale" is itself derived from the graduations on weighbeam-type instruments), as in Figs. 6 and 7. The third basic type of weight balance varies the moment of the known weight by swinging it away from a fulcrum in a *pendulum* manner (Fig. 5).

Beam Ratio

Beam ratio, or beam arm ratio, refers to the effect of inequality in length of the two arms of an equal-arm weight balance. It is expressed in parts/million as follows: Suppose an equal-arm balance in equilibrium

WEIGHT

A survey of weighing techniques, including the various types of weight, spring, current, buoyancy and load-cell equipments.

M. H. ARONSON

WEIGHT is the force with which a mass is attracted toward the center of the earth by gravity. It is measured by applying an opposing force of known magnitude, which balances the unknown force (weight). Its importance in measurement cannot be overestimated—all measurements refer ultimately to the three fundamental measurements of length, time, and mass. The conversion factors for units of mass are given in Table 1.

There are six basic methods for weight measurement—that is, six basic types of opposing forces: (1) a known *weight,* (2) a *pneumatic* force, (3) *spring* force, (4) *bouyancy* force, (5) magnetic force due to *current*, and (6) reaction of an elastic solid, hydraulic or pneumatic *load cell.*

Weight Balances

The use of a known weight as the opposing force is perhaps the most accurate of all quantitative measurements because the force due to weight is determined directly by the invariable force of gravity. Weights are used in several different types of balances and scales, usually being compared on opposite side of a *weighbeam.*

Beam Balance Fundamentals

A few fundamental factors about levers and beam systems should be kept in mind when selecting or operating weight-balance systems. One is the relation between center-of-gravity of the system and sensitivity of the balance.

TABLE 1—CONVERSION FACTORS FOR UNITS OF MASS

Values in boldface are exact values

Units of mass less than pounds and kilograms

Unit		Grains	Apothecaries' scruples	Pennyweights	Avoirdupois drams	Apothecaries' drams	Avoirdupois ounces
1 grain	=	**1**	**0. 05**	0. 041 666 67	0. 036 571 43	0. 016 666 7	0. 002 285 71
1 apothecary scruple	=	**20**	**1**	0. 833 333 3	0. 731 428 6	0. 333 333	0. 045 714 3
1 pennyweight	=	**24**	**1. 2**	**1**	0. 877 714 3	**0. 4**	0. 054 857 1
1 avoirdupois dram	=	**27. 343 75**	**1. 367 187 5**	1. 139 323	**1**	0. 455 729 2	**0. 062 5**
1 apothecary dram	=	**60**	**3**	**2. 5**	2. 194 286	**1**	0. 137 142 9
1 avoirdupois ounce	=	**437. 5**	**21. 875**	18. 229 17	**16**	7. 291 67	**1**
1 apothecary or troy ounce	=	**480**	**24**	**20**	17. 554 28	**8**	1. 097 142 9
1 apothecary or troy pound	=	**5 760**	**288**	**240**	210. 651 4	**96**	13. 165 714
1 avoirdupois pound	=	**7 000**	**350**	291. 666 7	**256**	116. 666 7	**16**
1 milligram	=	0. 015 432 356	0. 000 771 618	0. 000 643 014 8	0. 000 564 383 3	0. 000 257 205 9	0. 000 035 273 96
1 gram	=	15. 432 356	0. 771 618	0. 643 014 85	0. 564 383 3	0. 257 205 9	0. 035 273 96
1 kilogram	=	15 432. 356	771. 617 8	643. 014 85	564. 383 32	257. 205 94	35. 273 96

Unit		Apothecaries' or troy ounces	Apothecaries' or troy pounds	Avoirdupois pounds	Milligrams	Grams	Kilograms
1 grain	=	0. 002 083 33	0. 000 173 611 1	0. 000 142 857 1	64. 798 918	0. 064 798 918	0. 000 064 798 9
1 apothecary scruple	=	0. 041 666 7	0. 003 472 222	0. 002 857 143	1 295. 978 4	1. 295 978 4	0. 001 295 978
1 pennyweight	=	**0. 05**	0. 004 166 667	0. 003 428 571	1 555. 174 0	1. 555 174 0	0. 001 555 174
1 avoirdupois dram	=	0. 056 966 146	0. 004 747 178 8	**0. 003 906 25**	1 771. 845 4	1. 771 845 4	0. 001 771 845
1 apothecary dram	=	**0. 125**	0. 010 416 667	0. 008 571 429	3 887. 935 1	3. 887 935 1	0. 003 887 935
1 avoirdupois ounce	=	0. 911 458 3	0. 075 954 861	**0. 062 5**	28 349. 527	28. 349 527	0. 028 349 53
1 apothecary or troy ounce	=	**1**	0. 083 333 33	0. 068 571 43	31 103. 481	31. 103 481	0. 031 103 48
1 apothecary or troy pound	=	**12**	**1**	0. 822 857 1	373 241. 77	373. 241 77	0. 373 241 77
1 avoirdupois pound	=	14. 583 333	1. 215 277 8	**1**	**453 592. 427 7**	**453. 592 427 7**	**0. 453 592 427 7**
1 milligram	=	0. 000 032 150 74	0. 000 002 679 23	0. 000 002 204 62	**1**	**0. 001**	**0. 000 001**
1 gram	=	0. 032 150 74	0. 002 679 23	0. 002 204 62	**1 000**	**1**	**0. 001**
1 kilogram	=	32. 150 742	2. 679 228 5	2. 204 622 341	**1 000 000**	**1 000**	**1**

Units of mass greater than avoirdupois ounces

Units		Avoirdupois ounces	Avoirdupois pounds	Short hundredweights	Short tons	Long tons	Kilograms	Metric tons
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1 short hundredweight	=	**1 600**	**100**	**1**	**0. 05**	0. 044 642 86	45. 359 243	0. 045 359 243
1 short ton	=	**32 000**	**2 000**	**20**	**1**	0. 892 857 1	907. 184 86	0. 907 184 86
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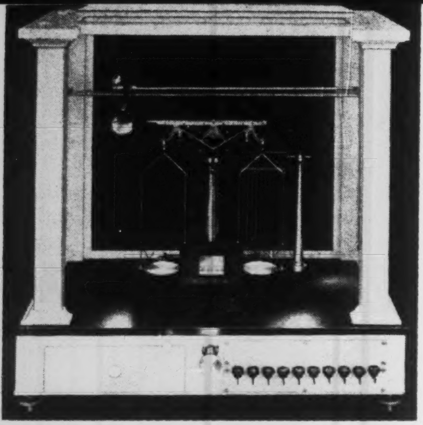

FIG. 1. TYPICAL analytical balance is enclosed equal-arm-weighbeam balance with microgram or milligram sensitivity. This one has SR of 2 ug/div; beam ratio of 5 ppm; projection-type readout indicator; keyboard for weight addition or removal. (Courtesy Wm. Ainsworth & Sons, Inc.)

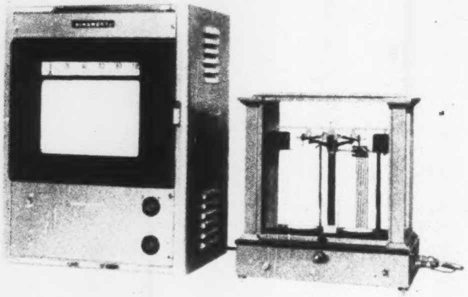

FIG. 2. This analytical balance uses LVDT on beam to develop signal for automatic recording. (Courtesy Wm. Ainsworth & Sons, Inc.)

has a 10-gram weight added to each pan, resulting in a reading of plus 2 divisions; when the weights are exchanged between pans the reading is minus 8 divisions. The average reading is minus 3 divisions. If the sensibility reciprocal (SR) is 10 ug/div (0.01 mg/div), 3 divisions represents 30 ug, which is 3 ppm of the 10-gram weight used. Hence the beam ratio is 3 ppm.

Note that the remaining 5-division swing of the indicator tells the inequality between the two weights—in this case 50 ug (the tolerance for Class-M 10-gram weights). Note how exchanging weights between pans tells *both* the beam ratio and the weight differences.

Commercial Features

The various features of weight balances are shown in the many commercial models available.

Fig. 1 shows a microbalance in which weights can be placed on the pan simply by touching the keys on a keyboard. This balance also has an optical projection system to magnify the pointer movement.

The most sensitive balances use no damping or air-damping. Liquid damping is the least common method.

Some balances can be supplied with *magnetic damping* of the weighbeam. The magnetic damper is an aluminum vane on the beam, which can move between the poles of magnets fixed to the case. Motion of the beam causes eddy currents in the vane. The eddy currents set up a magnetic field opposite to the fixed magnetic field, braking the motion and bringing the beam to equilibrium rapidly.

Undamped balances are usually read by noting the so-called turning point of the pointer as it moves across the graduations. The swing of a balance pointer on the first oscillation if no "kick" has been introduced will be approximately twice the rest point. The exact rest point can be determined from the swinging pointer by taking the mean of two readings to the left and one reading to the right (or vice versa) and adding algebraically, then dividing by two. This is common practice in reading a swinging undamped microbalance.

Fig. 2 shows a modern analytical balance with recorder output. Automatic recording permits weight *changes* to be examined, as in evaporation, diffusion, oxidation, absorption, drying, etc. The balance shown has a capacity of 200 grams, a sensibility reciprocal (SR) of 1 mg/div (0.1"), and over-all accuracy of ±0.2 mg over the automatic recording range. It also features automatic weight switching—that is, when recorder pen approaches the edge of the chart, a 100-mg increment is either added or taken off the pan automatically, which returns the pen to the opposite edge of the chart. A total of 4 grams can be handled automatically. Air damping is used.

The recording is done by attaching a linear variable differential transformer to the balance weighbeam. A similar recording technique has been reported by Dr. A. Peterson*. The Peterson technique increased the sensitivity of a milligram analytical balance so that fractional microgram weight changes were recordable.

Substitution Principle

In the balances shown in Fig. 3 the single sample pan and the weights are suspended from the same end of the beam. When a weight is placed on the pan, an equivalent amount of known weight is removed from the beam so that the total load remains constant. This is called the *substitution principle*. The weights, added or subtracted manually by dials, are totalled on a counter for direct readout and can be printed out (in some models) to 8 places. A projection readout unit increases the sensitivity.

Industrial Milligram and Gram Weight Balances

A line of industrial balances is shown in Fig. 4. A shows an even-arm solution balance for rapid weighing of solutions. B shows use of multiple

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*Dr. Axel Peterson, "Analytical Balance Plus Differential Transformer Plus Recording Millivoltmeter Equals Sensitive Recording Microbalance," *INSTRUMENTS & AUTOMATION*, July, 1955, pages 1104-1106.

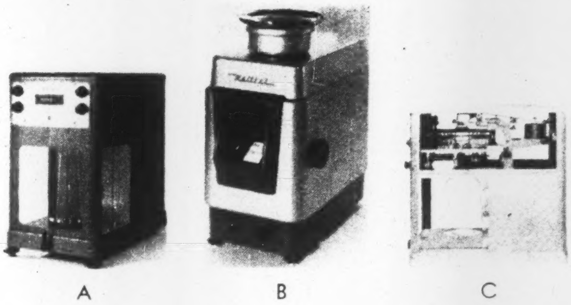
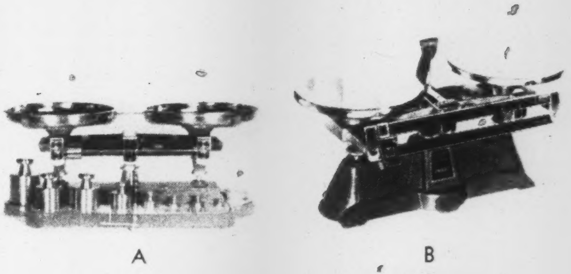


FIG. 3. BALANCES using substitution principle. A shows Mettler B-5; B shows Mettler K-7; C shows Ainsworth "Right-A-Weigh" with digital readout or printed readout to 7 places—0.1 mg in 199.9 grams.



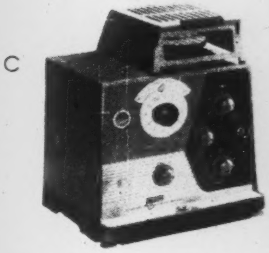


FIG. 4. TYPICAL industrial-type milligram and gram balances. A shows micrometer poise; B shows multiple beams for range extension; C shows balance in which weight is added by chain alone. (Courtesy Ohaus Scale Corp.)

beams, each carrying a different weight so that a large range can be covered without adding or removing weights. D shows a special moisture-determination balance wherein the weight is added to the beam via a chain connected to a calibrated dial. A heating element covers the pan; balance is indicated by a shadow-type vane.

Industrial Pound Weight-Balance Scales

High-load industrial weight-balance scales usually use compound levers or "pendulum" action.

Weight-balance type scales in which weights alone produce the restoring force, but which have dial indication, are shown in Fig. 5. Here the imposed load causes pendulum-type weights to swing out, producing a restoring moment of force. Accuracy of 0.1% is possible. Ranges are from several hundred to several thousand pounds; the large dial permits a 1500-lb scale with one-pound graduations.

Fig. 6 shows the way in which levers can be compounded to produce a weight-balance scale for heavy industrial loads, such as trucks or railroad cars.

Fig. 7 shows a weight-balance industrial scale controlling weight on a conveyor. Material on the weighbelt is balanced against a known movable weight on the weighbeam. Any deviation of the beam from balance operates one of two mercury switches, which in turn operate the bin gate to control the weight of material on the conveyor.

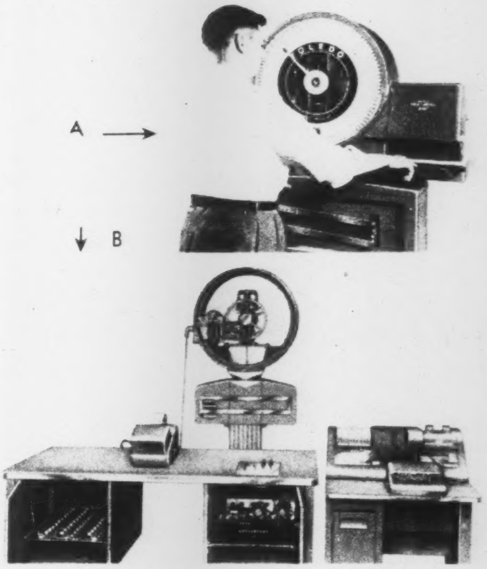
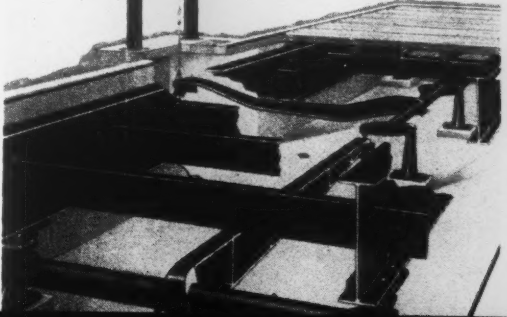


FIG. 5. PENDULUM-TYPE weight-balance scales. A shows a Toledo Scales instrument with printer; B shows Fairbanks, Morse system with printout and card punch.

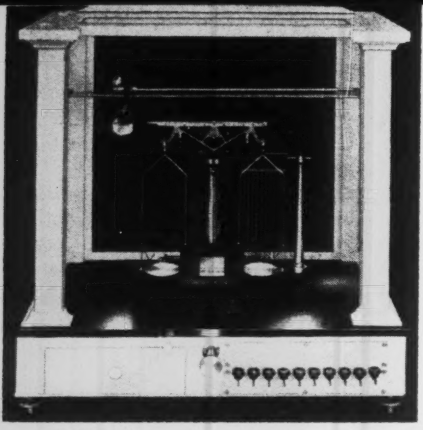
FIG. 6. COMPOUND-LEVER weighbeam balance for heavy industrial use. (Courtesy Winslow Government Standard Scale Works.)



Pneumatic Balance

In all balances described thus far, weights were used to produce the force that balanced the weight of the unknown mass. Fig. 8 shows a scale that produces an opposing *pneumatic* force, using weighbeam technique.

Weight on the conveyor produces a downward force at point 7. This is balanced by an opposing pneumatic force at point 10. If the opposing forces are not equal, the beam is unbalanced, causing nozzle (9) to be covered or uncovered, raising or lowering the pneumatic pressure so that the forces are balanced; the



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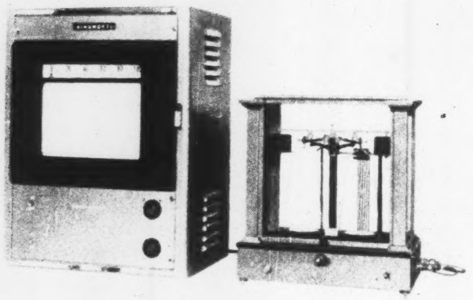

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*Dr. Axel Peterson, "Analytical Balance Plus Differential Transformer Plus Recording Millivoltmeter Equals Sensitive Recording Microbalance," *INSTRUMENTS & AUTOMATION*, July, 1955, pages 1104-1106.

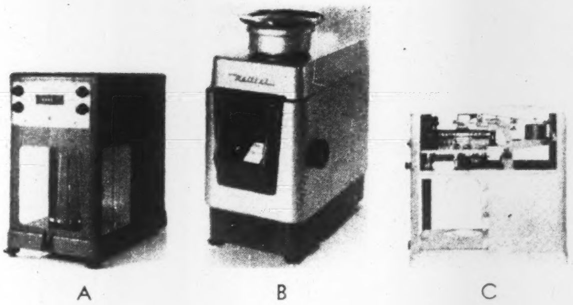


FIG. 3. BALANCES using substitution principle. A shows Mettler B-5; B shows Mettler K-7; C shows Ainsworth "Right-A-Weigh" with digital readout or printed readout to 7 places—0.1 mg in 199.9 grams.

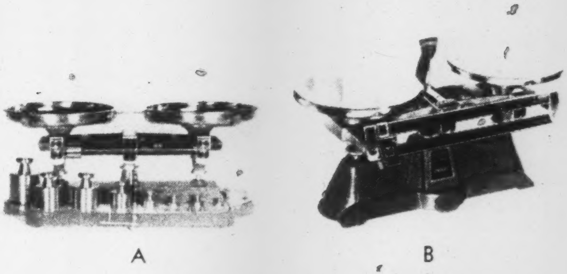
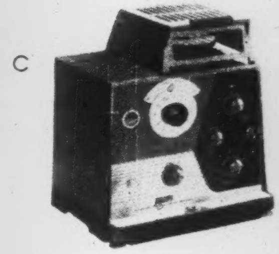


FIG. 4. TYPICAL industrial-type milligram and gram balances. A shows micrometer poise; B shows multiple beams for range extention; C shows balance in which weight is added by chain alone. (Courtesy Ohaus Scale Corp.)



beams, each carrying a different weight so that a large range can be covered without adding or removing weights. D shows a special moisture-determination balance wherein the weight is added to the beam via a chain connected to a calibrated dial. A heating element covers the pan; balance is indicated by a shadow-type vane.

Industrial Pound Weight-Balance Scales

High-load industrial weight-balance scales usually use compound levers or "pendulum" action.

Weight-balance type scales in which weights alone produce the restoring force, but which have dial indication, are shown in Fig. 5. Here the imposed load causes pendulum-type weights to swing out, producing a restoring moment of force. Accuracy of 0.1% is possible. Ranges are from several hundred to several thousand pounds; the large dial permits a 1500-lb scale with one-pound graduations.

Fig. 6 shows the way in which levers can be compounded to produce a weight-balance scale for heavy industrial loads, such as trucks or railroad cars.

Fig. 7 shows a weight-balance industrial scale controlling weight on a conveyor. Material on the weighbelt is balanced against a known movable weight on the weighbeam. Any deviation of the beam from balance operates one of two mercury switches, which in turn operate the bin gate to control the weight of material on the conveyor.

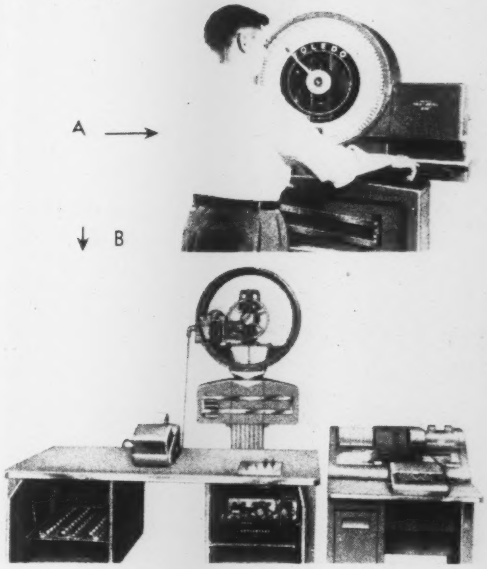


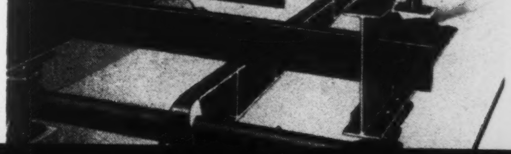
FIG. 5. PENDULUM-TYPE weight-balance scales. A shows a Toledo Scales instrument with printer; B shows Fairbanks, Morse system with printout and card punch.

Pneumatic Balance

In all balances described thus far, weights were used to produce the force that balanced the weight of the unknown mass. Fig. 8 shows a scale that produces an opposing *pneumatic* force, using weighbeam technique.

Weight on the conveyor produces a downward force at point 7. This is balanced by an opposing pneumatic force at point 10. If the opposing forces are not equal, the beam is unbalanced, causing nozzle (9) to be covered or uncovered, raising or lowering the pneumatic pressure so that the forces are balanced; the

FIG. 6. COMPOUND-LEVER weighbeam balance for heavy industrial use. (Courtesy Winslow Government Standard Scale Works.)



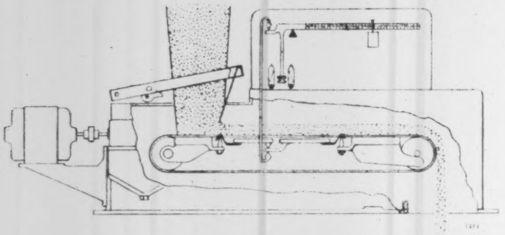


FIG. 7. MERCHEN scale feeder is weight-balance scale with control switches. (Courtesy Wallace & Tiernan, Inc.)

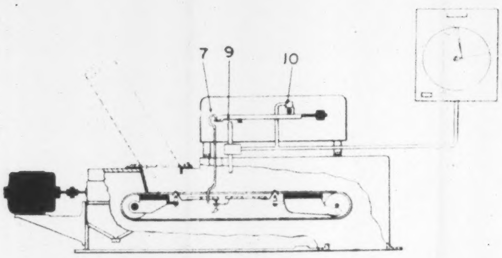


FIG. 8. MERCHEN pneumatic scale feeder is pneumatic-balance mechanism. (Courtesy Wallace & Tiernan, Inc.)

beam is again the equilibrium. At this time the pneumatic pressure will be exactly proportional to the weight.

The advantage of using a pneumatic pressure output is that the pneumatic force can be transmitted to remote indicators and used to control mechanisms such as the feeder gate shown in Fig. 8.

Spring Scales

The term "spring scale" applies to any weight instrument wherein the opposing force is developed by a spring element or spring action, including beam *deflection* (bending).

Spring Fundamentals

Centuries ago, Robert Hooke discovered that deflection of a spring-like material is proportional to load. Calibrated springs have been used ever since to measure load and weight. As springs are susceptible to several possible types of errors, it is important to know their limitations and accuracies.

The characteristics of a spring that can produce errors include:

1. *Deviation* of response from true linearity—that is, from Hooke's Law response. This occurs primarily at larger loads.
2. *Creep*, or plastic flow, which occurs when the spring is extended past its elastic limit. This causes a "permanent set"—that is, the spring does not recover completely when load is removed. There can also occur a slow elastic after-effect—that is, a slow deflection that occurs after the initial deflection and which looks like a set, but which recovers completely in a similar slow manner after the load is removed. This is called recoverable drift.
3. *Hysteresis*, the difference between the response in one direction (increasing load) and the other (decreasing load), even though the end points are the same. Hysteresis errors for usual spring materials are between 0.1 and 0.2% of the total deflection; for Iso-Elastic* it is 0.02%.

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*Iso-Elastic is an alloy developed by John Chatillon & Sons.

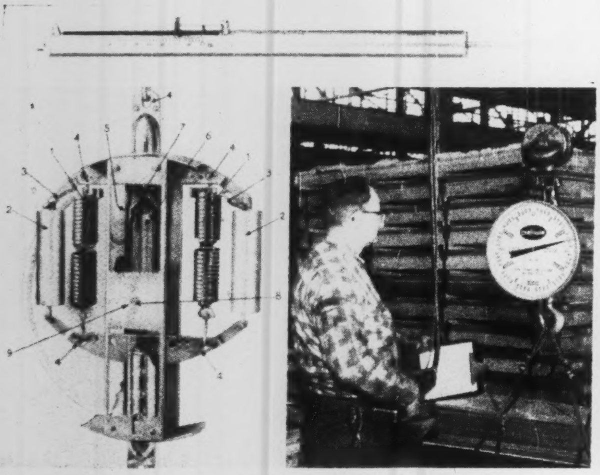

FIG. 9. TYPICAL spring scales. Top shows simple push-pull steel-spring gage; bottom shows "Iso-Seal" dynamometers with Iso-Elastic springs for 0.5% accuracy. (Courtesy John Chatillon & Sons)

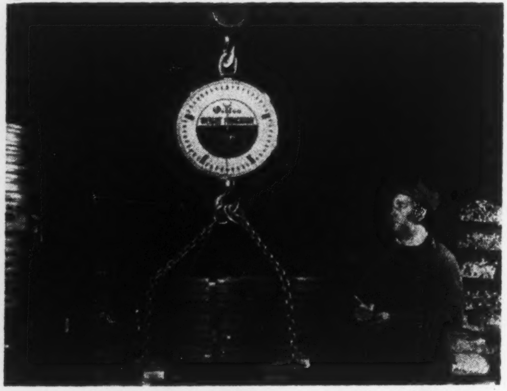

FIG. 10. INDUSTRIAL dynamometer in which beam deflection acts as opposing "spring" force. (Courtesy W. C. Dillon & Co.)

4. *Temperature error* due to thermal coefficient. This is the change in spring rate resulting from temperature change.

Table 3 lists the orders of magnitudes of these several effects, for various common spring materials.

Fig. 9 shows some scales using springs as the restoring-force element.

Dynamometers of the type shown in Fig. 10 are a type of spring scale wherein deflection of an alloy steel beam (only a few ten-thousandths of an inch) is translated by levers directly into dial indication of weight. This type of scale is used for weights in the range from a few hundred pounds up to 100,000 pounds or more. Accuracy is normally 2% of full scale. The range and accuracy make it suitable for many industrial applications—steel, parts, bins, trucks, loads, etc. These applications include torque, tension, traction and compression.

Fig. 11 shows use of the linear variable differential transformer with elastic members. In one weight-platform application, the weight-platform is opposed by a spring connected to an LVDT. The interesting feature of this system is that the primary winding of the LVDT receives a signal proportional to belt speed, while its core is positioned by the weight-spring combination. Hence the signal output of the LVDT is a mass-flow signal (lbs/sec). This signal is used to control a variable-speed drive which adjusts the speed of the conveyor to deliver any desired of amount of material per second.

Combination Weight and Spring Balances

The advantage of weight balance is accuracy; that of spring balance is rapidity of reading. Combinations of the two techniques are used to obtain relatively high accuracy with faster reading than can be obtained by weight-balance alone.

Fig. 12 shows a "Basic Weight Classifier" in which an equal-arm weighbeam is used to balance the unknown weight against a known desired weight. The *amount of unbalance* is indicated on a "Shadograph" indicator, which is a vane connected between two U-shaped torsion elements. Neither element is bent when the beam is in balance, but one or the other is bent when the beam is out of balance, producing the restoring force. Unbalance can be converted into binary-coded signal by attaching a coded dial with photocells to the indicator.

One feature of this system is that the center of gravity of the weighbeam element is on the range line, so that the scale need not be exactly level. Basic use is in rapid sorting, and a complete line of comparison weighers and sorters is available using this principle.

Combination weight-balance plus spring indication of the unbalance also is used in the balance shown in Fig. 13. Here again the desired weight of sample is placed on the pan on the left side, and the unknown on the right side. Unbalance deflects a delicate torsion member; the degree of unbalance is indicated on the scale, which is readable to .1 microgram in the 0-1 mg model. Other models are available to 0-2500

TABLE 3—SPRING CHARACTERISTICS

Material	Temperature Coefficient of Modulus of Elasticity /°F	
Spring Steel	-190×10^{-6}	
Chrome Vanadium	-146×10^{-6}	
Phosphor Bronze	-200×10^{-6}	
Brass	-216×10^{-6}	
Beryllium Copper	-194×10^{-6}	
Iso Elastic	-15×10^{-6} to $+10 \times 10^{-6}$	
	Drift in 1 Hour	Drift in 24 Hours
Spring Steel	0.08%	0.30 %
Iso-Elastic	0.01%	0.06 %
Spring Steel (½ Load)	0.02%	0.065%
Iso-Elastic (½ Load)	Not Detectable	0.01 %
	Creep at 200 F	Creep at 500 F
Spring Steel	0.25%	5 %
Iso-Elastic	0.02%	0.1 %

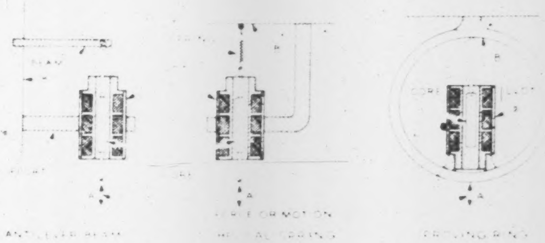

FIG. 11. LVDT use with elastic members. (Courtesy Schaevitz Engineering.)

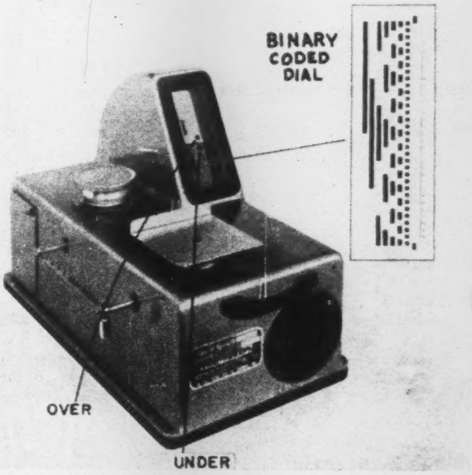

FIG. 12. BASIC WEIGHT Classifier uses weighbeam and spring technique to obtain accuracy plus speed. (Courtesy The Exact Weight Scale Co.)

FIG. 13. "SAUTER Ultra-Matic" precision balance. (Courtesy August Sauter of N. Y., Inc.)

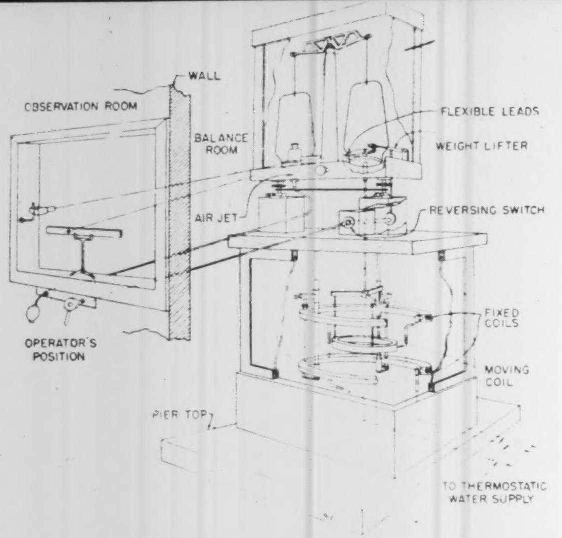

FIG. 14. THE RAYLEIGH current balance. (Courtesy the National Bureau of Standards).

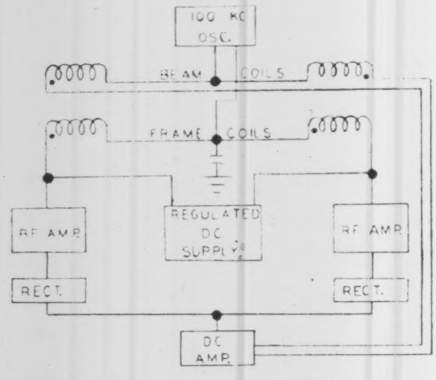

FIG. 15. Principle of 301 B balance.

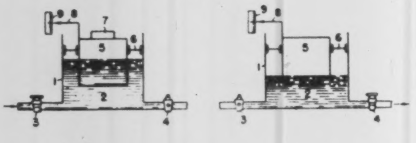

FIG. 16. TOP, buoyancy weighing with analytical balance. Below, principle for metering an exact amount of liquid using buoyancy. (Courtesy Gulf Research & Development Co.)

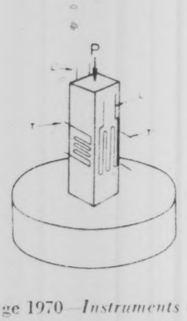

FIG. 17. STRAIN-GAGE load cell. Gages L and L' are load-sensing gages; T and T' are temperature-compensating gages. (Courtesy Baldwin-Lima-Hamilton Corp.)

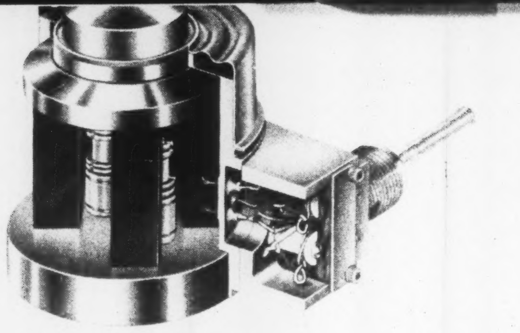

FIG. 18. MULTI-COLUMN strain-gage load cell. (Courtesy Cox & Stevens Div., Revere Corp. of America).

ing. Air damping is used. Note that analytical balance sensitivity is obtained with the rapid reading speed of a spring-type balance.

Current Balance

The standard ampere is established by a *current balance* (Fig. 14), which uses a coil hung from the weighpan of an analytical balance. This coil hangs within two stationary coils connected in series but the connections to the fixed coils can be reversed. When current is on in one direction the moving coil pulls down. The balance is brought to equilibrium by counterbalance weights. When current is switched, the electromagnetic force acts to lift the coil and an exact compensating weight is placed on the weighpan to which the coil is attached. Thus the ampere is defind and established in terms of weight.

The 301 B of E-H Research Laboratories (Fig. 15) is an automatic analytical balance featuring a current-balance technique and 1-sec response time.

Four air-core coils are mounted on the balance—two at either end of the beam and the other two immediately underneath, attached to the frame. The 100-kc oscillator excites a mutual inductance bridge consisting of the 4 coils. This bridge measures the position of the beam with respect to the frame; discriminator action is obtained by rectifying and subtracting the two r-f outputs. The d-c signal so obtained is applied to the beam coils to restore the balance to null. The frame coils are excited by a regulated d-c power supply whose stability determines the accuracy (0.1%) over ranges of 30 to 3000 mg full scale.

Buoyancy Balance

Several types of analytical balances with high weighbeams are available with special accessories for buoyancy weighing. These accessories include plummets of known volumes for use in measuring the specific gravity of liquids by buoyancy effect, as shown in Fig. 16. The volume of a mass can be measured by buoyancy if the specific gravity of the liquid is known.

Fig. 16 also shows a technique for metering an exact amount of liquid using bouyancy. A known weight is placed on the float at left and fluid is pumped into the unit until the indicator registers a given or "null" point. The inlet valve is then shut and the weight is removed. The outlet valve is then opened until the same "null" point is indicated. A weight of liquid exactly equal to that of the original weight will have been metered out.

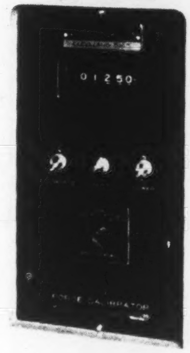

FIG. 19. FORCE calibrator has precision strain-gage assembly. (Courtesy Gilmore Industries)

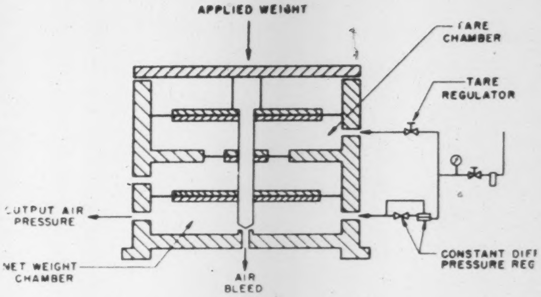

FIG. 20. PNEUMATIC weight transmitter. (Courtesy CDC Control Services, Inc.)

Load Cells

A load cell is an element that develops an electric, pneumatic, or hydraulic signal which is proportional to the load placed upon it.

The *strain-gage load cell* (Fig. 17) consists of a high-strength steel column on which a strain-gage matrix has been bonded. As a load is placed on the column, the column is compressed slightly and the fine-wire gage is strained uniformly with the steel column. This lessens the electrical resistance of the grid in proportion to the strain applied. Electronic instrumentation measures the change in resistance and coverts it into a signal proportional to the weight of the load applied to the cell*.

The multi-column strain-gage load cell shown in Fig. 18 has four strain gages bonded to each of four supporting columns, resulting in a high-output voltage in a small-size cell.

Fig. 19 shows a "Portable Force Calibrator" which can be used to calibrate existing weight measuring systems. It has digital readout with accuracy of 0.1% of reading, or 0.1% of lowest range, whichever is greater. The indicator uses a continuous balance servo system and is calibrated with a precision strain-gage load cell for tension or compression.

Pneumatic load cells (Fig. 20) develop a pneumatic signal proportional to the applied load. Air pressure in the Net Weight Chamber will automatically adjust itself to develop an upward force exactly equal to the downward force of the applied weight. The Tare Chamber is used to cancel the dead weight load on the scale. Note absence of knife edges and levers, sources of hysteresis and friction. A common application is in weighing of bulk materials on conveyors and in proportioning. The pneumatic signal is particularly useful in pneumatic control systems.

Fig. 21 shows a "Ratio Totalizer" that accepts up to three input pneumatic signals and delivers an output pneumatic signal equal to the difference or ratio (products, proportions, etc.) between the inputs. This has many uses in weight control with pneumatic transmitters and control systems.

Hydraulic load cells (Fig. 22) use a closed liquid-filled system whose pressure is increased by applied load. The pressure causes a Bourdon-tube deflection. These are available in many sizes for industrial use, as shown in Fig. 23.

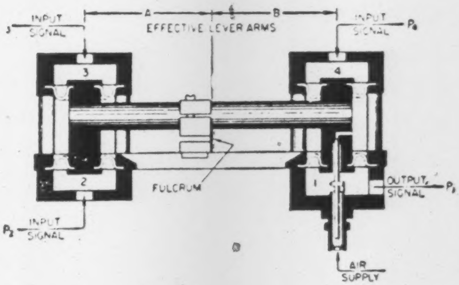

FIG. 21. RATIO Totalizer can give output signal equal to the difference or ratio or products of several input pneumatic signals. (Courtesy Hagan Chemicals & Controls, Inc.)

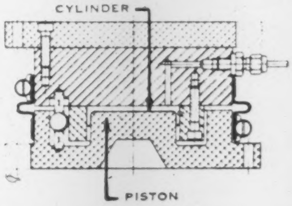

FIG. 22. WEIGH-PAC" hydraulic load cell. (Courtesy A. H. Emery Co.)

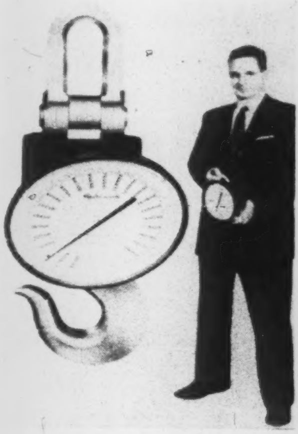

FIG. 23. WIDE range of hydraulic scales is available. (Courtesy Hydroway Scales, Inc.)

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*Strain gage issue, *I&A*, March 1958; also book *Strain Gage Instrumentation*, Aronson and Nelson, Instruments Publishing Co., 1958.

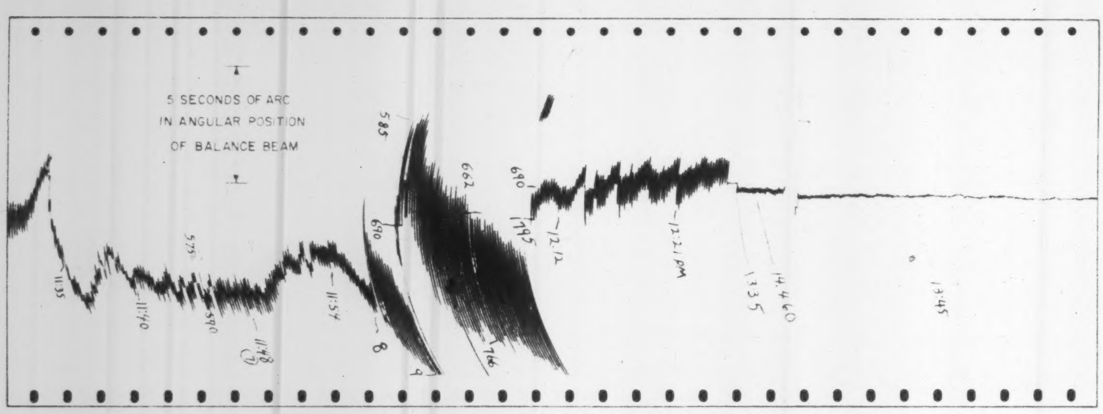

FIG. 1. CONTINUOUS RECORD of balance-beam motion made with automatic reading device. At left, balance was under the influence of unstable air masses caused by small thermal disturbances inside the balance case. At right, after the air had become quiescent, only low-level background "noise" is detected. Note that operation of the reader was suspended for about 70 minutes starting at approximately 12:24, beginning again at 13:35.

AUTOMATIC READER FOR

This photoelectric device, developed by the National Bureau of Standards, automatically and continously follows beam position of a precision balance, indicating it to 0.0001″ and increasing the readability sensitivity 40 times. Turning-point readings also are improved.

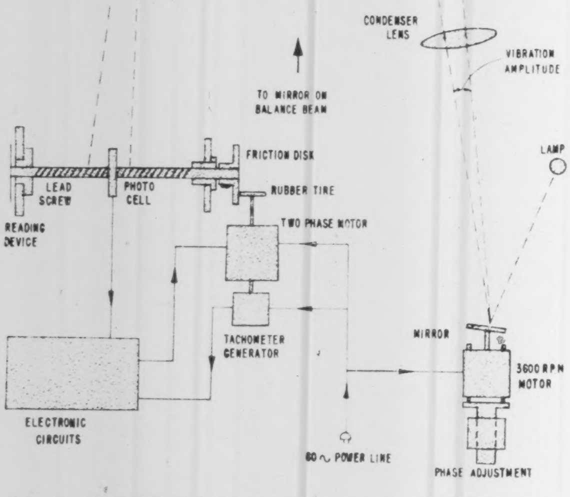
CONDENSER LENS
VIBRATION AMPLITUDE
TO MIRROR ON BALANCE BEAM
LAMP
FRICTION DISK
LEAD SCREW
PHOTO CELL
RUBBER TIRE
READING DEVICE
TWO PHASE MOTOR
TACHOMETER GENERATOR
MIRROR
3600 RPM MOTOR
ELECTRONIC CIRCUITS
60 ∿ POWER LINE
PHASE ADJUSTMENT

FIG. 2. BLOCK PLAN of the automatic reader for precision balances.

THIS PHOTOELECTRIC beam-position recorder and amplitude indicator was developed primarily as a research tool for obtaining a better understanding of balance errors; data from such studies are now being accumulated and will be used in working out improved balance designs. The photoelectric reader can provide data on the motion of the balance beam in two forms: (1) as a voltage whose magnitude represents the instantaneous position of the beam; or (2) as numerical data that represent turning points (extreme dimensions of the swing), from which masses can be calculated in conventional manner. A plot of output voltage (Fig. 1) can be used in evaluating the dynamic characteristics of the oscillating structure. The turning points are read off from a dial that ordinarily indicates the instantaneous position of the beam, but which holds for a brief interval after each turning point is reached.

Operation of Reader

A fixed, single-filament lamp shown at far right in Fig. 2 is the source of light. The light is first reflected

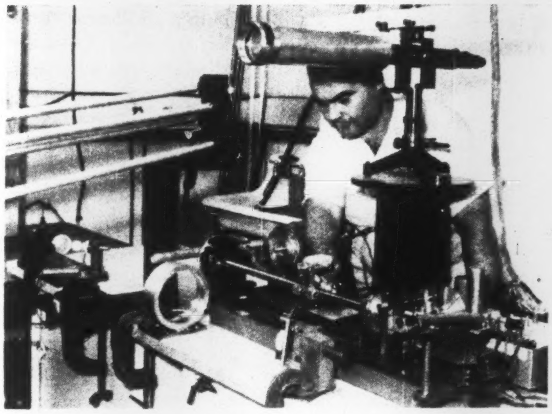

FIG. 3. PHOTOCELL IS here brought into initial alinement with the light beam. Telescope (above) is used for conventional visual observations of the balance beam.

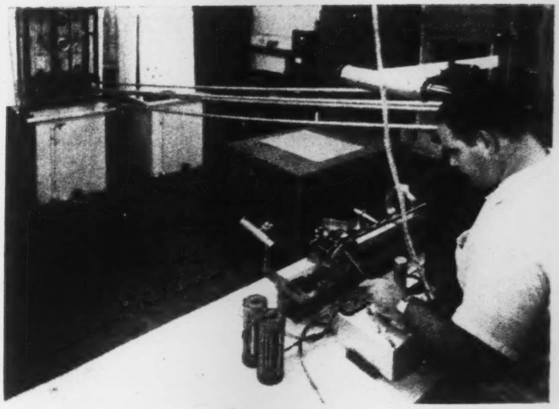

FIG. 4. READER IS on table in foreground; balance (upper left) is manipulated by long rods. The operator is noting the turning-point position of the balance beam as indicated on reader dial; the dial remains stationary for a short interval after each turning point because of built-in backlash.

PRECISION BALANCES

L. R. MACURDY and **H. A. BOWMAN**

National Bureau Of Standards

from a rotating mirror whose plane is tilted slightly from the plane normal to the axis of rotation. A simple arrangement allows the angle of tilt to be set at any value up to 1 minute of arc. The mirror is rotated by a 3,600-rpm motor so the reflected light beam oscillates at 60 cps with a peak-to-peak amplitude adjustable from 0 to 2 minutes of arc. Phase can be adjusted with respect to the 60-cps power supply by rotating the motor in its mount.

After reflecting from the rotating mirror, the light beam passes through a condensing lens and proceeds to the balance. A mirror mounted on the balance frame directs the beam to a mirror on the moving arm (beam) of the balance. The light beam is reflected back to the photocell and produces an image of the lamp filament on the plane of the photocell slit: the slit and filament image are both about 3/64″ wide.

This filament image oscillates at 60 cps through a distance of about 3/16″. When the slit is located in the center of this vibration it is illuminated 120 times a second. However, if it is displaced from the center of the vibration, the electrical output of the photocell will contain a 60-cps component whose phase and magnitude depend, respectively, on the direction and amount of the off-center displacement.

The 60-cps component is filtered, amplified, and applied to the control winding of the two-phase motor. This motor then drives the lead screw in the proper direction to recenter the slit, provided that the supply voltage used to excite its reference winding is in appropriate phase with the 60-cps vibrations of the light beam. (Relative phase of the light beam is adjusted by rotating the 3,600-rpm motor.)

Thus the photocell (Fig. 3) is made to follow the swinging light beam to within about 0.0002″, corresponding to 4×10^{-5} degree in the angular position of the balance arm. A tachometer generator provides a velocity-damping signal to prevent oscillations around the servo loop.

The position of the balance arm at any instant can be determined accurately from the angular position of the lead screw, which is coupled mechanically to the pickoff arm of a precision potentiometer. The lead screw is 20″ long with a two-start thread, 10 pitch, ground from SAE 6150 steel hardened to Rockwell c55. It has a 0.0004″ lead error fairly well distributed along

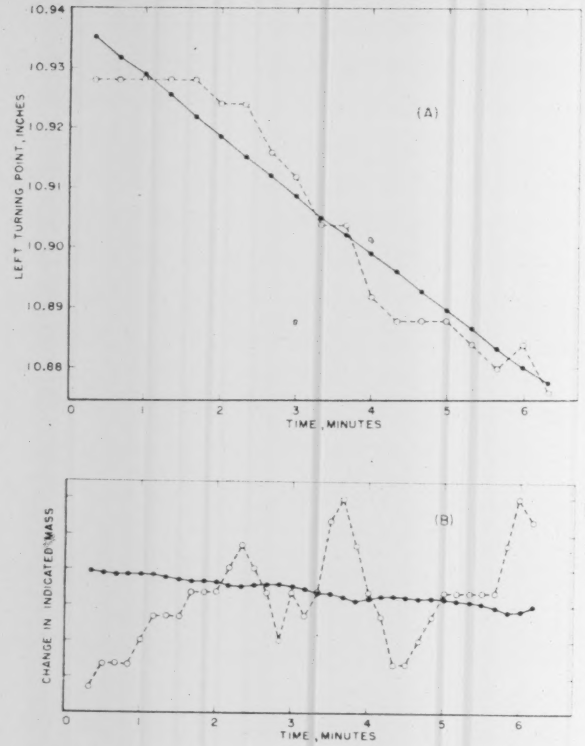

FIG. 5. A SHOWS data obtained from observations of a high-precision balance by conventional visual method (open circles) and by use of new photoelectric reader (black circles). B shows the corresponding computed values (using both left and right turning points) of the indicated mass.

its length, and is driven by a rubber tire and friction disk. The plane of the thrust bearing supporting the disk provides a reference from which displacement measurements of the photocell are made.

The reading dial at the left end of the lead screw (Fig. 4) has 100 graduations spaced about 1/8″ apart, each representing 0.001″ of photocell displacement. This dial has one turn of free play so that it remains motionless for one revolution of the lead screw when the latter reverses direction. During this interval the turning-point reading remains unchanged, permitting the operator to make an accurate estimate of the extreme position of the photocell to 1/10 of a division, or 0.0001″.

Background Noise

Zero stability of the apparatus, determined from observations on a light beam reflected from an arrested (and therefore presumably motionless) balance, is about 2 microinches per minute. This drift changes direction roughly twice daily, and may therefore be associated with some diurnal motion of the building or piers. There are occasional bursts of "noise" of about ±0.0003″, some of which have been correlated with starting and stopping of building elevators. However, the total effect of all noise (see extreme right of Fig. 1) is not considered serious enough to warrant additional noise studies at this time.

Comparison with Conventional Reading Method

The effectiveness of the automatic reader as a tool for investigating the errors of precision balances rests on the considerable improvement in reading accuracy that it provides. This improvement appears clearly from the results of a test in which readings were taken simultaneously by the old and new methods. An experienced telescope observer made readings "on the fly" of the turning points in the moving image of a millimeter scale, reading directly to millimeters and estimating tenths of millimeters. Another observer read off the turning points from the motionless dial of the photoelectric device, reading directly to thousandths of an inch. Results are shown in Fig. 5A. The dial readings produced the smoother curve. Calculations of mass made from these turning points appear in Fig. 5B. Note that many readings by eye would have to be made and averaged to achieve the accuracy of the photoelectric reader. Hence readings can be made more rapidly with the latter, reducing temperature-transient errors, a factor in precise work.

Errors in Precision Mass Measurements

Major errors in precision mass measurements are due to small changes in temperature and humidity that occur during the course of the experiment. The automatic reader makes it possible to increase the speed of balance operations by from 5 to 10 times and thus shortens the interval during which these changes in ambient conditions can act. Faster operation also increases the "on scale" range of balance; this permits the use of larger and hence more accurate weights. The disadvantage of high-speed operation is that it ordinarily results in losses of readability and deflection sensitivity. However, the high reading sensitivity of the present instrument more than compensates for these losses.

The reader is being used currently to evaluate mechanical features that are under consideration for inclusion in a short-period high-precision automatic weighing system. A number of useful results already have been obtained. In one study, for example, the device has been used to show the effects of errors associated with a certain type of arrestment mechanism, while another has shown the reloading error in a balance of one design when operated without arrestment.

Acknowledgements

Design and construction of the apparatus are due primarily to *L. B. Macurdy*, chief of the NBS mass unit, and *H. A. Bowman* of the Mechanical Instruments Section. Consultation was provided by *M. L. Greenough* and *T. R. Young*, also of the Bureau staff; the instrument was fabricated largely in the Bureau's instrument shop.

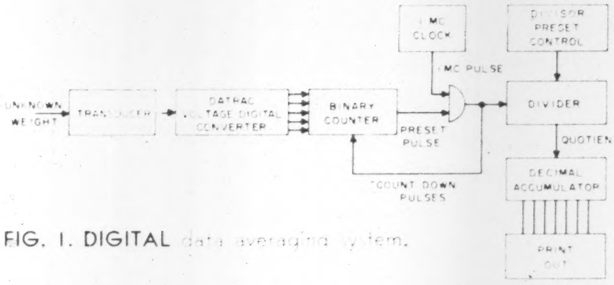

FIG. 1. DIGITAL data averaging system.

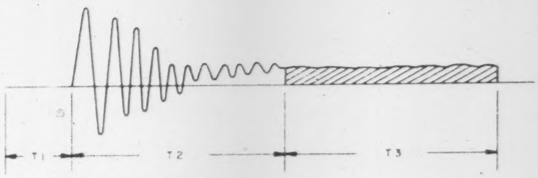

FIG. 2. TYPICAL SIGNAL INPUT. T1 is pre-measurement delay; T2 is high-frequency transients interval; T3 is low-frequency transients interval. Shaded area shows available averaging time.

WEIGHING FAST FREIGHT

JOHN F. LAFONTAINE
Epsco, Incorporated

A "WEIGHTRAC" system for weighing rolling moving freight is shown in Fig. 1. The unknown weight is monitored at the input by a conventional load cell. The voltage output from this cell is proportional to the weight of the vehicle, modulated by any vibrations in the scale mechanisms and oscillations in the vehicle being monitored. This weight information is sampled approximately 500 times (per vehicle) by the converter to effect 500 digital codes that are transmitted through parallel lines to a binary counter. Subsequent to each counter preset operation, a gate is opened which passes that number of 1-megacycle pulses which are necessary to run the counter backwards to zero.

The gated clock pulses employed for count down are routed through a digital divider circuit and into a decimal accumulator. The division factor is set equal to the number of samples constituting one measurement (500) so that the total number of pulses received at the accumulator input is the digital average of the 500 samples. When all 500 quotients have been accumulated, their binary-coded decimal sum is fed to a printout where the four-decimal digit average is displayed as an accurate measurement of the unknown weight.

A typical voltage input from the transducer is shown in Fig. 2. The T1 interval (pre-measurement delay) is the time required for one car to move off the weighing mechanism and for the next to move on. When the vehicle to be weighed moves onto the transducing apparatus, its motions and weight produce vibrations which result in noise transients of considerable magnitude and duration; these are shown in the interval marked T2.

The transient interval T2 occupies a major portion of the time the vehicle is on the weighing apparatus when the vehicle moves at high speeds; thus the available sampling time is limited. While the high digitizing speed of the DATRAC would permit 500 samples to be taken in a transient-free interval (T3) of less than 12.5 milliseconds, logic operations required between data samples in the present configuration require a total sample period of two milliseconds per sample. Consequently, the over-all measurement interval cannot be less than one second.

The purpose behind the averaging approach is to filter out the low-frequency noise that is always present during the weighing time, even after the vibration-produced transients have disappeared. This low-frequency noise varies from two to six cps. Sampling this signal 500 times, which is tantamount to continuous averaging, eliminates the effects of input dynamics. The entire system up to the print-out mechanism is essentially a complex non-linear filter wherein operational digital techniques* are employed to average binary data.

If the dynamic data is to be averaged out of the signal, each measurement must be made as accurately as possible. Pen recordings of the load-cell output showed that the oscillation frequencies and amplitudes were such that accuracy could not possibly be obtained with a digitizing interval of more than 50 microseconds. A slower conversion speed would result in some of the 500 samples being accurate and others being inaccurate, which would cause an over-all degradation in final measurement accuracy.

The problems encountered in this application, such as noise transients and rapidly changing dynamic data are, to some extent, characteristics of every industrial data-handling application. Unless this fact is recognized, as a result of more thorough investigations of process dynamics and data transmission problems, analog-to-digital converters which purport high accuracy will continue to supply industry with inaccurate or insufficient information. The real and significant advantages offered by analog-to-digital conversion can be realized only through high-speed implementation.

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*"Adapting Digital Techniques for Automatic Control," Bernard M. Gordon, Epsco, Incorporated, Boston, Mass.

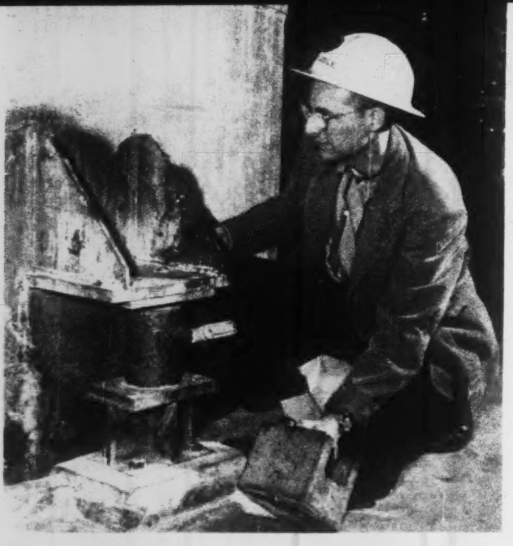

FIG. 1. **LOAD CELL** supporting a batching tank.

Batch Weighing

Automatic batch-weighing equipment is now available for complete automation of batching programs involving mixtures of many ingredients added at different times, plus equipment operation between steps.

A BATCH-WEIGHING SYSTEM should have a weight-sensing element with the following qualities: It should be small, light, moisture-proof, corrosion and shock-resistant. Its output should be linear and stable (repeatable). It must retain these characteristics over a reasonable range of temperature. Adequate frequency response, ability to withstand overloads, and long-term stability without maintenance also are important. Operation in hazardous environments may make low operating voltages and currents a requirement. Further, since most weight applications require the weights of more than one element, it must be possible to sum outputs.

Strain-Gage Load Cell

Let us consider the Baldwin-Lima-Hamilton SR-4 load cell with respect to these specifications. The load cell (Fig. 1) senses strain in a short metal column by a group of bonded-filament strain gages affixed to the column. As the column is designed to operate at relatively low stress levels, strain is proportional to stress: resistance change can be calibrated in terms of load.

As the design strain level is well below the proportional limit, Hooke's law applies. This is modified to some extent by Poisson's effect and the fact that the modulus of steel changes with stress. The characteristic of a straight column cell is parabolic, but the deviation from the best-fit straight line (as observed over the past years) runs below 0.1% of full scale at the point of maximum nonlinearity.

Over the past fifteen years several steel and nonferrous alloys have been tested for load-cell use. Only a few have been found to combine the proper linearity and creep characteristics with those of strength and homogeneity. Strain-gage technology has progressed to the state where non-repeatability is considered negligible. This is due mainly to the technique for applying the gage to the column. Reproducibility of electrical output versus applied load on a short term basis is readily made 1 part in 400 and, with certain manufacturing selection, 1 part in 10,000.

Temperature Effects

There should be no change in output with temperature, under load or at no load. No-load temperature compensation is attained by applying four strain-gages to the column and connecting them in a four-arm bridge. The four gages are chosen to have equal thermal coefficients of resistivity, thus maintaining the net bridge resistance change with temperature to a minimum. Some small bridge-balance change is observed because gage resistances and thermal coefficients are not exactly equal and because the thermal coefficient of the column is different from that of the gages: compensation for this effect has produced a standard line of cells where temperature effect on zero load is less than 0.0015% of full scale.

Temperature effect on output under load is caused primarily by change in Young's modulus with temperature. In steel, this is in the vicinity of +2% per 100F°. Compensation is accomplished by placing a temperature-sensitive resistor in series with the input leads of the bridge. When the value of this resistance and its thermal coefficient are chosen properly, and the resistor is in such a location that it is at the same temperature as the column, the bridge output will be temperature stabilized. Thus, it is possible to guarantee a temperature effect on sensitivity (output) to 0.0008% of load per Fahrenheit degree.

Column Characteristics

Design deflections for column-type cells run in the vicinity of 4 to 6 thousandths of an inch. Therefore, in a common case (50,000-pound load cell), the spring constant is approximately 10^7 pounds per inch, and the frequency response is flat to 1000 cps. The natural mechanical frequency is 5000 cps.

SR-4 load cells are rated conservatively as to effects

Presented at the Fourth International Automation Exposition, New York City, N. Y. June 9-12, 1958.

with Load Cells

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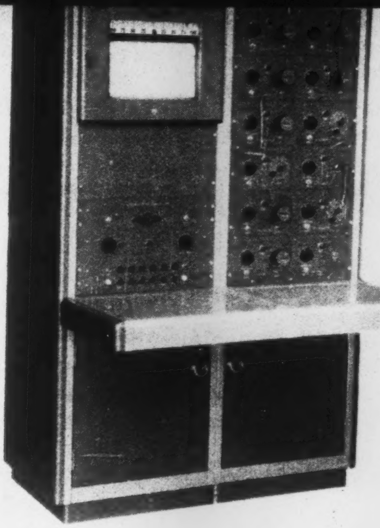

FIG. 2. SPECIAL BATCHING controller. Batching controller can control 12 ingredients as to weight and sequence. Fail-safe system prevents either under or over weight.

of overloads. An overload up to two times the cell capacity will not damage the cells. Between 120% and 150% of rated load, slight zero shifts may be observed but the measuring qualities of the cells will not be impaired. In this overload range the zero shift is believed due to the gage taking a new set on the column. Zero shifts always will be experienced between 150% and 200% of rated load. Cells will be damaged if these loads are applied repeatedly. Further, there is the danger that calibration will be affected.

Electrical Parameters

Operation of BLH load cells is generally permissible in explosive atmospheres or other hazardous environments. The input voltage to the cells is between 6 and 10 volts. Bridges used in most cells are 120 ohms, so current is less than 100 milliamperes. Power requirements never run higher than 800 milliwatts.

The cells are small; the most widely used 100,000-lb compression cell is 7⅝" high and 5" in diameter. Weight is approximately 21 lb.

The cells are moisture proof. Though operation under water is scarcely recommended, all seams and joints are welded or brazed together during cell assembly, lead wires between cable entry box and cell go through a hermetic glass-to-meal seal, and the cable entry box is filled with potting compound after attachment of the cable. SR-4 cells are in use where the atmosphere is corrosive and where the cells are in contact with corrosive chemicals.

Maintenance is negligible because there are no moving parts in the usual sense of the term. The gage bond does not deteriorate; no knowledge of cell failures due to wear exists.

Summation of outputs is handled easily. When a-c excitation is used, outputs can be added directly by placing them in a series string and reading the total output directly. When using d-c excitation, cells are usually paralleled, the total output reading being an average which can be calibrated in terms of the total load.

Instrumentation

The signal output of the load cell can be amplified and observed on a dial-type meter, or used to energize relays. Although direct amplification systems are inexpensive, their accuracies are only 1 or 2%.

More commonly, voltage null-balancing type instrumentation is used with two bridges—one in the instrument and the other in the transducer. The difference in voltage between the two bridges is amplified and used to power a motor which drives a slide-wire contact in a direction which reduces the difference signal to zero. This null-balance method is in extensive use, yielding instrument accuracies commensurate with those of the transducer.

Equipments using this principle are available (Fig. 2) for control of up to twenty-four ingredients. The sequence of batching of the ingredients can be changed quickly. Manual, semi-automatic or completely automatic operation is possible whereby the instrument is programmed to introduce all ingredients at proper sequence and according to the weights determined by formula.

Fail-safe features protect against power failure, empty hoppers before the quantity of ingredients desired is reached, valve or gate sticking, etc.

The following procedure used by Phillips Chemical Company illustrates an automatic program:

1. 25% caustic solution is introduced.
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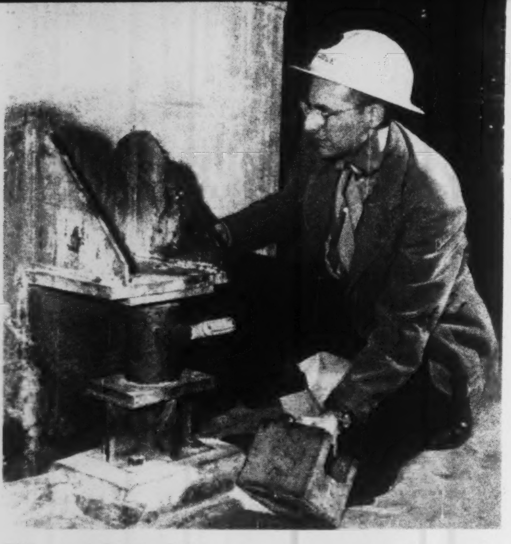

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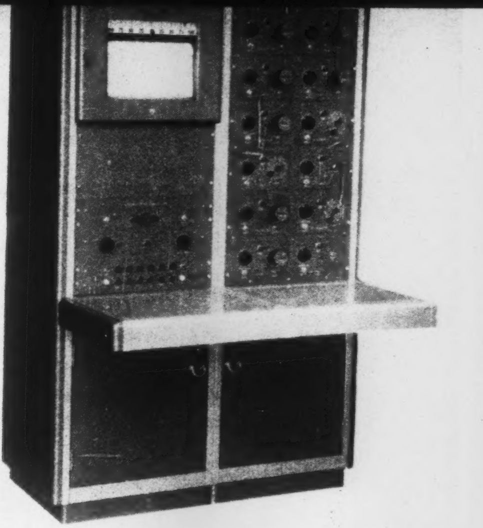

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Weighing While Conveying

Automatic weighing while conveying can have many advantages over batch weighing, including savings in space and cost for hoppers and feeding equipment. Integrating scales can weigh to within 0.5%.

ROBERT O. BRADLEY
Toledo Scale Corporation

AUTOMATIC WEIGHING while conveying usually means applying an integrating scale to a belt conveyor where one or more of the existing conveyor idlers transmit the *weight* of a known length of the conveyor belt and its load to the weighing device. A belt speed pickup provides a signal proportional to belt *speed*. The signals from the scale and belt speed pickup are fed into an integrating device, which essentially multiplies weight per foot by feet per minute in order to obtain the weight which has passed over the unit in a given period of time.

Accuracy

The system accuracy of a well designed and maintained integrating conveyor scale can be 0.5% if the following features are observed:

1. The unit should have provisions for balancing out the light and heavy sections of the conveyor belt when it is running empty. This requires an integrating device which can run in the reverse direction when a lighter-than-average section of belt is passing over the weighed section of the conveyor. This eliminates *low-load errors*.
2. The belt speed pickup should be driven by the *carrying* strand of the conveyor belt at a point adjacent to the weighed section of conveyor, rather than being driven by the return strand. This eliminates *belt-tension errors*.
3. The conveyor idlers that are on the scale should be supported with minimum deflection in relation to the fixed idlers on the conveyor frame. This eliminates *deflection errors*.
4. The weighing idlers should be restrained from moving laterally and longitudinally with respect to the conveyor in order to avoid force couples which impair weighing accuracy under certain conditions. This eliminates *lateral-motion errors*.

Low-Load Errors

Some integrating scales have an integrator which cannot run in a reverse direction. As these units do not integrate near the zero point, an arbitrary zero is set by placing weights equal to approximately 10% of full capacity on the scale and then adjusting the integrator so that it records that load correctly. The span setting is then made by placing a higher load on the scale and making certain that the difference in the two readings is correct.

Errors can occur at low flows due to the fact that the integrator cannot move until a fairly large percentage of the rated capacity is flowing over the scale. Thus, a leading increment of material at the beginning of load application is lost, as is a trailing increment.

One of the most common errors is *zero drift*. When the integrator can run in a reverse direction it is easy to check zero when the belt is running without load by noting whether the integrator is travelling forward or reverse, or whether it is standing still, as it should.

Belt-Tension Errors

When the belt-speed pickup is mounted on the return strand of the conveyor belt, it runs at a lower speed than the belt across the scale when the belt is carrying the load being integrated. This is because the carrying strand of the belt is under tension and is stretched, whereas the return strand is relaxed and unstretched. Consequently more feet of belt per minute pass over a point on the weighing strand when the belt is under load than pass over the belt-speed pickup pulley or a point on the return strand. In other words, the stretched section moves at higher velocity than the relaxed section. Hence the belt speed pickup should be on carrying strand of the belt (adjacent to the scale) if speed error is to be avoided.

Deflection Errors

Some scales that use mechanical techniques, such as levers, permit deflection of the weigh idlers (scale) below the stationary idler (platform) at high loads. This motion of the weigh idler below the plane of the stationary idlers can result in error because a smaller percentage of the load is supported on the weighing mechanism. This error results both from the belt tension and the "beam effect" on the belt.

Some manufacturers recommend use of a so-called "constant belt-tension device." Such a device will take up the stretch in the belt but will not eliminate the change in belt tension; the errors are made more repeatable but are not eliminated.

The "beam effect" of a conveyor refers to the fact

Presented at the Fourth International Automation Exposition and Congress, Coliseum, New York, N. Y., June 11, 1958.

that when the weighing idlers are out of plane, the conveyor belt acts as a beam partially supported by the fixed idlers adjacent to the scale and partially supported by the scale idlers. This "beam strength" of a rubber conveyor belt will vary as much as 20-30% with normal temperature changes and conditions of flexing. If the deflection in the weigh roll support becomes so great that the restoring force of the belt is as much as 20% of the restoring force of the weighing device, a 20% change in the characteristics of the belt would introduce a 4% error in weighing. If we wish to achieve a maximum allowable error of 0.5%, the belt errors due to beam effect should be kept to approximately 0.1% with restoring force in the belt no greater than 0.5-1% of the total restoring force.

The deflection errors discussed are caused by deflection of the weighing mechanism. Load cells, which are inherently low-deflection devices, have insignificant errors of this type.

Electrohydraulic Actuator

An addition to the two previous articles on "Response of Combination Valve Actuators."

Kearfott 6100 Actuator

The Kearfott 6100 servo valve is shown in Fig. 1.

Fig. 2 shows the operation of the electrohydraulic valve. Fluid under supply pressure (500 to 3000 psi) passes through fixed orifices to the chamber at either end of the spool. The spool has two passages leading to the two variable orifices located at either side of the spool's center line. A slider fork, part of the motor armature, closes the two variable orifices at null. The torque motor consists of a permanent magnet flux field, two field coil windings, the armature and a field return structure. The armature is pivoted. The only moving parts are the spool and the torque-motor armature.

An increased current flow through either winding displaces the armature about the pivot and moves the slider fork. The slider movement uncovers one variable orifice. Flow of fluid through this uncovered orifice lowers the pressure in one spool chamber; higher pressure in the other chamber moves the spool. The spool continues moving and stops when the exposed orifice slides under the fork. The pressures in each of the chambers at the end of the spool will then be at equilibrium. Movement of the spool to the right connects the supply pressure port P with load port L_1. Similarly, load port L_2 is connected with drain port D.

Equalizing the flow of current through the two windings restores the slider to the center or null position.

Fig. 3 shows the response of the 6100 servo valve.

Characteristics include: Quiescent flow—.05-.15 gpm; supply pressure—500 to 3000 psi; flow rate range—0.15-10 gpm; Weight—22 ounces; differential current—±15 milliamps; d-c resistance—3500 ohms; natural frequency—350 cps.

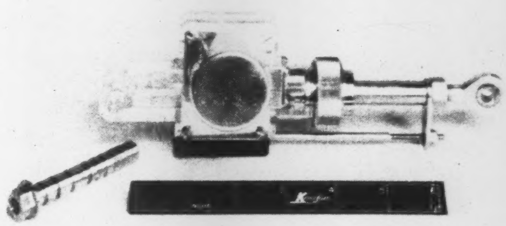


FIG. 1. THE KEARFOTT 6100 actuator.

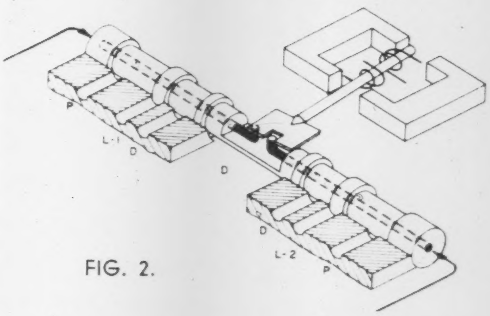
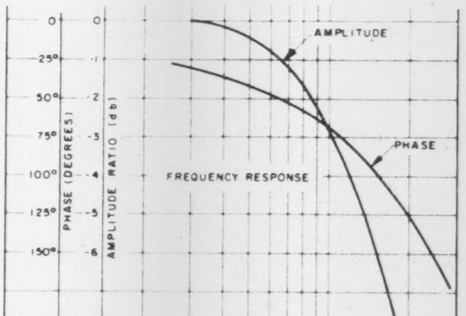


FIG. 2.

FIG. 3. FREQUENCY response.



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One of the most common errors is *zero drift*. When the integrator can run in a reverse direction it is easy to check zero when the belt is running without load by noting whether the integrator is travelling forward or reverse, or whether it is standing still, as it should.

Belt-Tension Errors

When the belt-speed pickup is mounted on the return strand of the conveyor belt, it runs at a lower speed than the belt across the scale when the belt is carrying the load being integrated. This is because the carrying strand of the belt is under tension and is stretched, whereas the return strand is relaxed and unstretched. Consequently more feet of belt per minute pass over a point on the weighing strand when the belt is under load than pass over the belt-speed pickup pulley or a point on the return strand. In other words, the stretched section moves at higher velocity than the relaxed section. Hence the belt speed pickup should be on carrying strand of the belt (adjacent to the scale) if speed error is to be avoided.

Deflection Errors

Some scales that use mechanical techniques, such as levers, permit deflection of the weigh idlers (scale) below the stationary idler (platform) at high loads. This motion of the weigh idler below the plane of the stationary idlers can result in error because a smaller percentage of the load is supported on the weighing mechanism. This error results both from the belt tension and the "beam effect" on the belt.

Some manufacturers recommend use of a so-called "constant belt-tension device." Such a device will take up the stretch in the belt but will not eliminate the change in belt tension; the errors are made more repeatable but are not eliminated.

The "beam effect" of a conveyor refers to the fact

Presented at the Fourth International Automation Exposition and Congress, Coliseum, New York, N. Y., June 11, 1958.

that when the weighing idlers are out of plane, the conveyor belt acts as a beam partially supported by the fixed idlers adjacent to the scale and partially supported by the scale idlers. This "beam strength" of a rubber conveyor belt will vary as much as 20-30% with normal temperature changes and conditions of flexing. If the deflection in the weigh roll support becomes so great that the restoring force of the belt is as much as 20% of the restoring force of the weighing device, a 20% change in the characteristics of the belt would introduce a 4% error in weighing. If we wish to achieve a maximum allowable error of 0.5%, the belt errors due to beam effect should be kept to approximately 0.1% with restoring force in the belt no greater than 0.5-1% of the total restoring force.

The deflection errors discussed are caused by deflection of the weighing mechanism. Load cells, which are inherently low-deflection devices, have insignificant errors of this type.

Electrohydraulic Actuator

An addition to the two previous articles on "Response of Combination Valve Actuators."

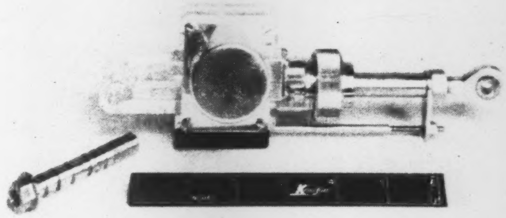


FIG. 1. THE KEARFOTT 6100 actuator.

Kearfott 6100 Actuator

The Kearfott 6100 servo valve is shown in Fig. 1.

Fig. 2 shows the operation of the electrohydraulic valve. Fluid under supply pressure (500 to 3000 psi) passes through fixed orifices to the chamber at either end of the spool. The spool has two passages leading to the two variable orifices located at either side of the spool's center line. A slider fork, part of the motor armature, closes the two variable orifices at null. The torque motor consists of a permanent magnet flux field, two field coil windings, the armature and a field return structure. The armature is pivoted. The only moving parts are the spool and the torque-motor armature.

An increased current flow through either winding displaces the armature about the pivot and moves the slider fork. The slider movement uncovers one variable orifice. Flow of fluid through this uncovered orifice lowers the pressure in one spool chamber; higher pressure in the other chamber moves the spool. The spool continues moving and stops when the exposed orifice slides under the fork. The pressures in each of the chambers at the end of the spool will then be at equilibrium. Movement of the spool to the right connects the supply pressure port P with load port L_1. Similarly, load port L_2 is connected with drain port D.

Equalizing the flow of current through the two windings restores the slider to the center or null position.

Fig. 3 shows the response of the 6100 servo valve.

Characteristics include: Quiescent flow—.05-.15 gpm; supply pressure—500 to 3000 psi; flow rate range—0.15-10 gpm; Weight—22 ounces; differential current—±15 milliamps; d-c resistance—3500 ohms; natural frequency—350 cps.

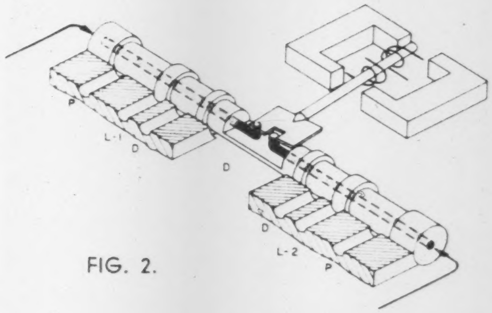
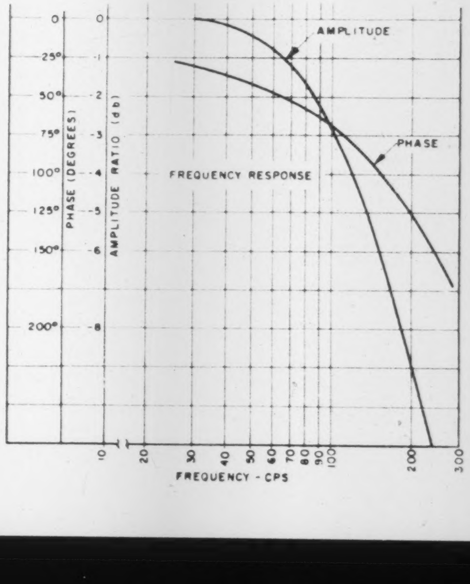


FIG. 2.

FIG. 3. FREQUENCY response.



Manometric Pressure Measurement

R. J. CARTIER, Trimount Instrument Company

For precision pressure measurement, correction for scale expansion, gravity, and fluid density, capillarity and compressibility may be required. Here is a technique for introducing all these corrections simply by adjustment of well diameter.

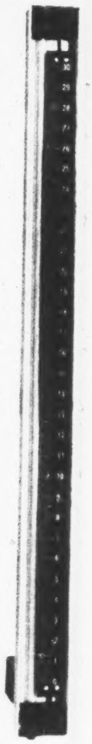


FIG. 1. WELL-TYPE manometer.

PRESSURE is one of the two most common measurements, the other being temperature. The manometer (Fig. 1) is the most common instrument for precision pressure measurement—yet the corrections essential to realize accuracy are not completely understood by many.

The relation between pressure (P) and manometer reading (h) in a well-type manometer is as follows:

$$h = \frac{P}{(M/V)g} \qquad (1)$$

where h is the distance between manometer minisci (cm or in); P is pressure (dynes/sq cm or poundals/sq in); M/V is density of manometer fluid (gm/cu cm or lb/cu in); g is acceleration of gravity (cm/sec^2 or in/sec^2).

Sources of Error

This equation shows that h is a measure of P only where g and M/V (density) are constant. The density will remain constant only at constant temperature; temperature change will cause not only a density change but also a scale expansion change which can be significant in long scales when large temperature differentials occur.

The value of g depends on location.

In addition to these two temperature effects and the gravitational effect, errors also can be caused by *capillarity* and *compressibility* of the fluid.

Although scale-expansion corrections are sometimes made by referring to charts or tables, or by correcting the scale itself, the other factors have not always been kept in mind. A technique for reducing *all* these errors to negligible values will be described.

Use of Tables, Charts, and Corrected Scales

The scale expansion due to a temperature change is:

$$s\ (t - t_o)\ h$$

where s is the linear coefficient of thermal expansion of the scale material; t is local temperature; t_o is reference temperature at which the scale reads correctly.

This correction can be used only if a uniform scale is used, but it often is tabulated for quick access to the correction factor. It also can be incorporated into the scale itself by adding to each scale increment the correction for one temperature. However, certification or verification of such a nonlinear scale is a difficult and costly procedure (a scale of 12″ length graduated in tenths of inches requires 121 separate measurements of non-standard lengths).

A more direct approach to scale-expansion correction is to vary the effective diameter of the well, as will be described. This same technique—which makes the change in level in the cistern equal to the desired correction—can be used to correct for density and gravity changes also.

Density and Gravity Corrections

Any fluid-density and gravity-force change from standard or calibrated conditions can cause error. The reading error per unit of scale is:

$$C = \frac{(M/V)_s - (M/V)}{(M/V)} + \frac{g_s - g}{g}$$

$$C = \frac{(M/V)_s}{(M/V)} + \frac{g_s}{g} - 2 \qquad (2)$$

where $(M/V)_s$ is the fluid density at standard conditions; M/V is density at local conditions; g_s is the acceleration of gravity at standard conditions; g the acceleration at local conditions.

Example: Suppose we have a mercury manometer at Chicago, and that it is to be used at 75° F.

The g at Chicago is 980.278 cm/sec².

Standard g (45° latitude and sea level) is 980.665 cm/sec² (32.1740 ft/sec²).

Standard mercury density* (specific gravity of mercury at 0° C) is 13.5951.

Density of mercury at 75° C is 13.5360.

$$C = \frac{13.5951}{13.5360} + \frac{980.665}{980.278} - 2$$

$$= 0.0047534$$

Note that this is a correction factor of 0.4%. These corrections can easily amount to 0.1″ in a 30″ column for various locations and temperature conditions throughout the USA.

We can use a scale graduated in *standard units* of length and apply this correction simply by adjusting the cistern diameter so that the change in level in the cistern exactly equals C. This technique consists of establishing the ratio between the internal diameters of the two manometer legs so that the change in level in one leg equals the desired correction for temperature and gravity (and also for other factors).

Establishing The Diameter Ratio

The relation between leg diameter and level change (Fig. 2) is

$$d^2/D^2 = H/h \qquad (3)$$

where D is inside diameter (ID) of larger well; d is ID of smaller well; H is cistern level change; h the reading level change. Hence the cistern diameter is

$$D = \sqrt{d^2h/H} \qquad (4)$$

Example: Using the Chicago example, we wish the level change H in the cistern to be 0.0047534″ for each 1″ change in h. The ID of the manometer leg is 0.500″.

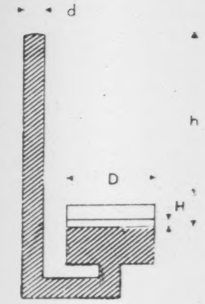


FIG. 2. LEVELS and diameters in well-type manometer.

h is 1 inch because we wish to apply the correction per inch of reading-leg height. Using these values in (4):

$$D = \sqrt{(0.5)^2/0.0047534}$$

$$= 7.2521'' \pm 0.0005''$$

The tolerance figure results from the fact that precision bore tube can be obtained to an ID accuracy of 0.0005″. This variation in D can be shown to cause a *maximum error* in h of less than ± 0.00001″ per inch of reading in the selected manometer.

Compressibility and Capillarity Correction

The compressibility correction is nonlinear—the higher the column the greater the compression of the fluid. This correction also can be made by changing the diameter of the cistern, as will be described.

The capillarity correction is a constant depending only on the surface tension of the fluid. This also can be taken care of in the cistern, being simply a vernier displacer like a zero correction.

Technique

The technique for adjustment of the well diameter is simple. As a matter of practice and convenience the area of the well is deliberately made oversize, after which the area is corrected by inserting a plug of known diameter. This provides the correction for one fixed local gravity and temperature. Compressibility and sealing column error* are corrected by tapering the plug, and capillarity by providing a vernier on the plug and using it as a displacer. It should be noted that the plug acts only as a displacer when correcting for capillarity. All other functions of the plug are as a convenient means of maintaining the area ratios.

The corrections described can easily amount to 0.1″ in a 30″ manometer. As this is within reading tolerance even without any optical reading aid, the corrections should be kept in mind and applied or incorporated as necessary.

Some manometers have reading aids that permit reading to 0.001″. It is obvious that all the corrections described must be applied if readings to this accuracy are to have any meaning.

---

*When water is used, the standard density is the specific gravity of water at 4°C (39.2°F).

*Sealing column refers to the column of liquid on top of the mercury in the well. Note: all correction techniques described are covered by appropriate patent applications.

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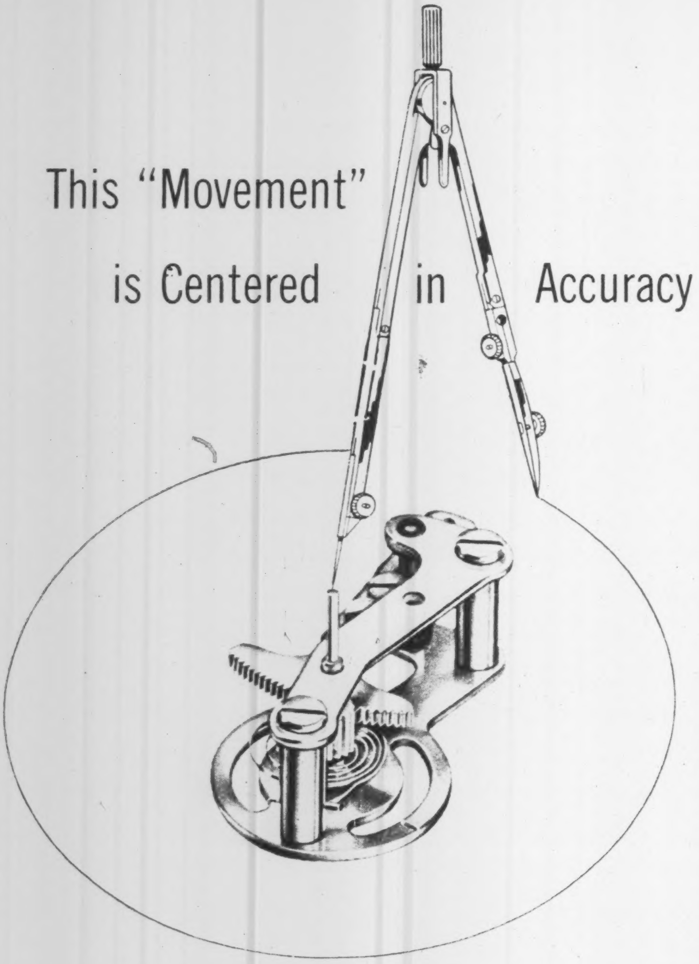

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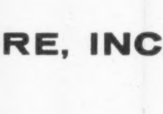

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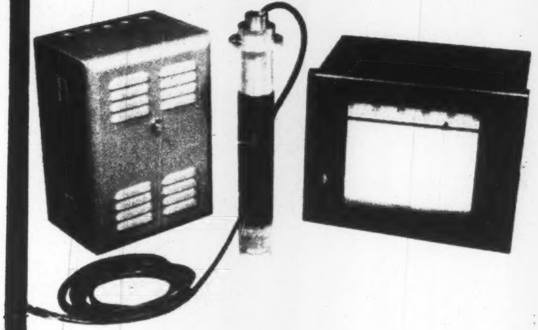


FIG. 1. POWER unit, probe and recorder.

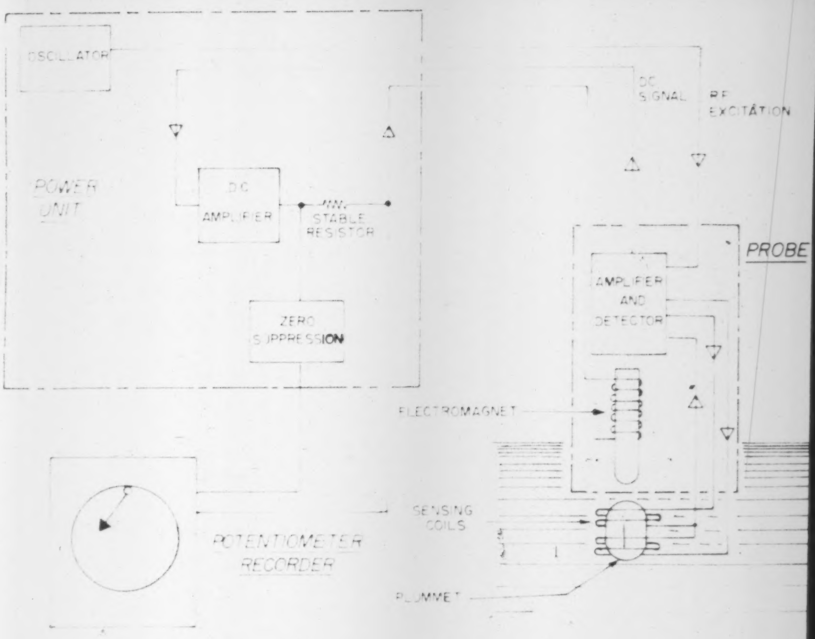


FIG. 2. BLOCK DIAGRAM

Electronic Density Probe

WILLIAM G. BURT, JR.
General Communication Company

POSITION SENSING COILS control the vertical position of an immersed plummet in this liquid-density detector (Fig. 1). These coils operate on a differential inductance principle, using radio-frequency excitation (Fig. 2). The plummet generates a signal in the coils whenever it moves from its "standard" or null position. This signal is brought back to the power tubes which control the current in an electromagnet winding which supplies the force that suspends the plummet. A complete servo suspension loop is thereby formed wherein the plummet is always positioned at the "standard" location within a fraction of a thousandth of an inch; this action is not affected by the presence of liquids in the plummet chamber, or by variations in liquid density.

With the plummet position maintained constant with respect to the pole-piece of the electromagnet, the inverse-square relationship of pole spacing is eliminated. Consequently the force suspending the plummet is a function solely of ampere turns for all practical purposes. It is necessary only to insert a stable resistance in series with the suspension coil to produce a current-derived output voltage proportional to the suspension force (density of liquid).

There is a tendency toward instability created by (1) the time lag between the change of magnetic force and its resulting movement on the plummet, and (2) the high gain required in the suspension loop. Stability has been achieved by applying differential and reset gain in addition to proportional gain.

The position sensing provisions in the probe include the sensing coils and the detector that converts the r-f position signal to a d-c signal. Up to 1,000 feet of cable can be used to connect the probe to the remaining elements of the system contained in the power unit mounted in the vicinity of the recorder. Any standard potentiometer recorder is usable and can include pneumatic and electrical controllers to control processes on the basis of liquid density.

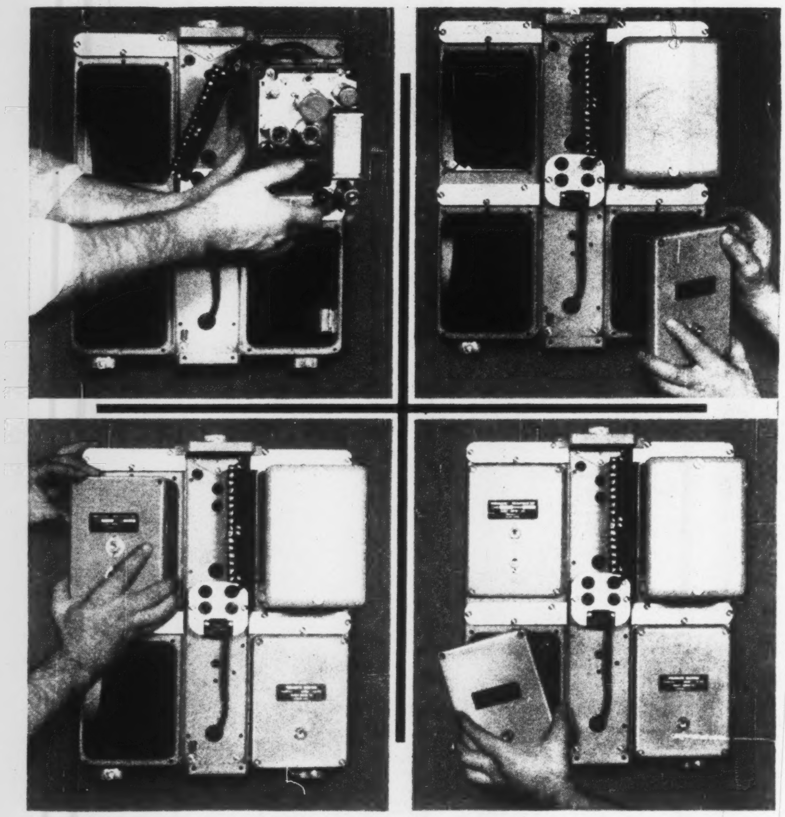
Plummet Sensitivity

The plummet design provides for internal loading to a net plummet density value slightly greater than the highest density to be measured. Under these conditions a small change in liquid density brings about a proportionately large change in the immersed weight of the plummet. Consequently, on short-span presentations the net resolution and repeatability of this instrument is of the order of ±0.00005 or better (in units of specific gravity). Due to a slight nonlinearity of the output voltage with reference to density, the overall accuracy is rated at ±3% of the span presented, using linear recorder scales. The exact span of density presented is adjustable together with the range, or starting point, by controls located on a range unit in the power unit chassis. The plummet used is a spheroid having a wall thickness of 1/32"; this will withstand static pressures up to at least 2,000 psi without damage.

This instrumentation has shown promise for use in oil pipelines and refineries, the manufacture of heavy chemicals such as sulfuric acids, the control of sugar content in food concentrates and in the extraction of mineral salts from natural deposits.

It can proportion ingredients and detect interfaces.

CUSTOM BUILD your own Bailey Recorder



These four views of the back of a Bailey Recorder show how four plug-in units may be added as needed to meet almost any recorder application.

The freedom and flexibility of "do-it-yourself" instrumentation is yours in the Bailey Recorder. A variety of plug-in units make it possible to record, control, and retransmit any variable that can be converted to a pneumatic or electric signal.

The basic plug-in units are the Bailey a-c and d-c Electronic Receivers and Pneumatic Receivers. Any four of these may be used in one recorder, intermixed in any way, to provide four continuous records on one chart.

For automatic control, other plug-in units are available.

For square root extraction or linear integration, there are two plug-in variations of the Bailey Integrator.

When you want a pneumatic signal that varies according to a pre-set pattern plug in a Bailey Program Controller.

Periodic running time of a condition or process is recorded on the chart when a Bailey Running Time Recorder is used.

These and other plug-in units are described in Product Specification E12-5. Some companies stock Bailey Recorder cases and assorted plug-in units. As instrumentation and control needs arise they build up the kind of recorder-controller required, using the proper plug-in units from stock. Unmatched versatility such as this means lower instrumentation costs.

For the complete story of how easily you can custom build this recorder to your needs, see your Bailey Engineer.

G43-1

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Bulk Material Programming

Automatic bulk-material weighing can be justified by improved quality control, in addition to material and time savings.

INGRAM H. RICHARDSON
Richardson Scale Co.

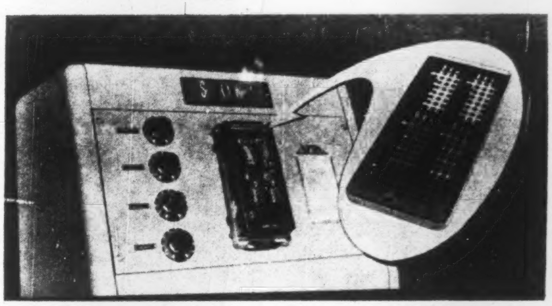

FIG. 1. **"BOSS BOARD"** weight selector is peg-type programmer.

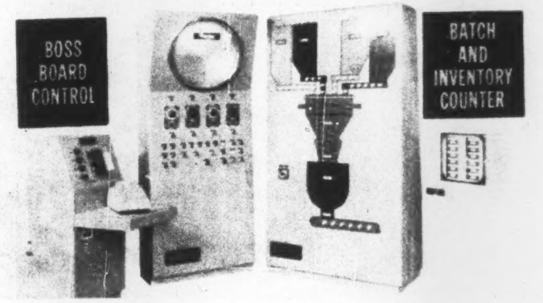

FIG. 2. **AUTOMATIC INGREDIENT** programming by weight selectors and patch board, with automatic read-out by indicating dial, automatic tabulating machine and remote inventory counters, in a four ingredient system.

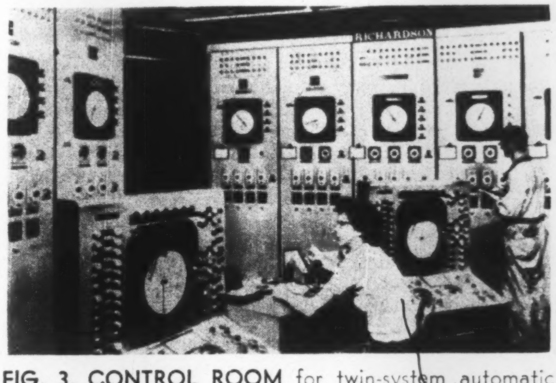

FIG. 3. **CONTROL ROOM** for twin-system automatic compounding in a rubber products plant.

BULK MATERIALS vary considerably in density and other physical properties. Automatic weighing and proportioning is of little value if the materials themselves cannot be made to flow under control. Thus the design of the bin and the selection of the feeder become as critical in an automatic weighing system as the scale mechanism itself.

With assured proper behavior of the bulk materials flowing through the process, then weighing scales can provide automatic proportioning of mixes and some accounting functions. The operation can be set manually or programmed by punchcard or tape and the resulting performance recorded on digital or analog recorders, or by automatic typewriters. Programming devices can establish the required command by peg contacts, speeding up the task of formula changing, batching, etc. (Fig. 1).

A synchro in the ingredient recorder can be used to drive individual counters to keep a perpetual inventory record for each ingredient as well as totalize the batch. An analog-to-digital converter and automatic tabulator can identify and record these weights with time and date coding. Similarly an automatic typewriter can print out all this data or it can be punched into cards for future data processing (Fig. 2).

Fig. 3 shows the control room for a twin proportioning system for a rubber product. In each system 6 carbon blacks, 9 oils, 12 accelerators, 8 pigments and 8 grades of pellet rubber are available to the Banbury mixer in the combination and quantities prescribed and selected by the one operator in the control room. Thus this one operator controls the flow of up to 86 ingredients, producing a batch every 2½ minutes and frequently changing formulas as called for by the production schedules. Circular-chart recorders establish a permanent record of the performance.

The automatic system can be interlocked with fail-safe control. Weigh hoppers must be in empty balance before the proportioning cycle can begin, and the automatic weighings must be accurate to within a prescribed plus-or-minus tolerance before the cycle can proceed. Any step of the operation which is not within tolerance puts the system in an alarm condition and the source of the trouble is indicated on the face of the panel.

Abstract of paper presented before the ASME Materials Handling Conference held in conjunction with the Fourth International Automation Exposition, New York City, June 9-13, 1958.

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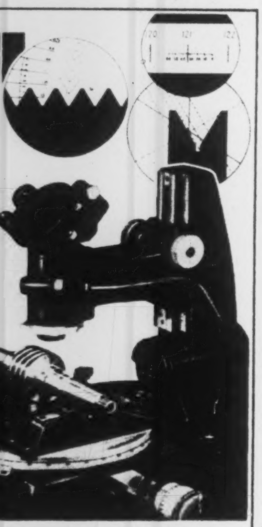

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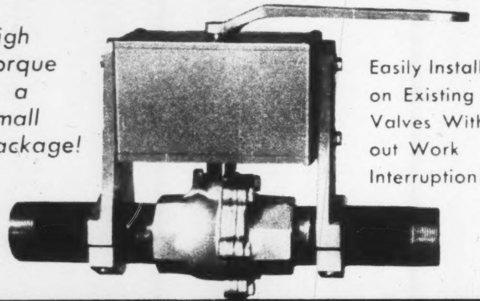

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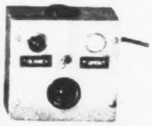

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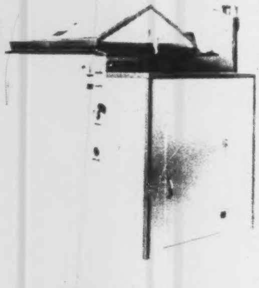

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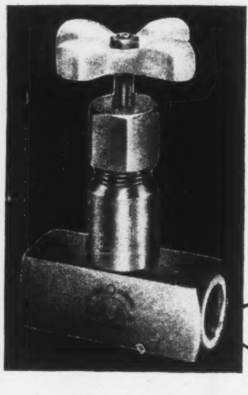

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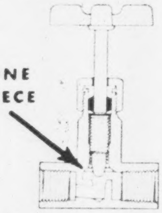

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ELECTRONIC CIRCUITRY

The circuit is the heart of all electronics. Here are 2 more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

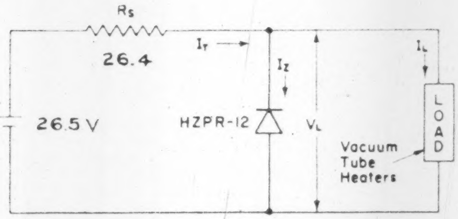
CHARLES F. KEZER
and
MILTON H. ARONSON

ZENER DIODE REGULATES D-C HEATER VOLTAGE

In vacuum-tube circuits such as d-c amplifiers, it is sometimes desirable to regulate heater voltages as well as plate supply voltage. In this circuit, a single Hoffman HZPR-12 zener diode can be used to regulate load currents for filaments up to 600 ma at 12 v dc.

Operating on the reverse-voltage part of its characteristic, the zener diode develops a voltage drop nearly independent of its current (comparable to the familiar gas-tube regulator). With input supply voltage V_i at its center value of 26.5 v dc, the zener diode draws a current of 250 ma, while 300 ma flows through the tube heater load. Load voltage (nominal 12 v) is 11.65 v dc.

When the input voltage drops to 23 v dc the zener diode current drops to 140 ma; voltage drop in the series resistor R_s decreases, and the load voltage drops by only 0.25 v. Similarly, when the unregulated voltage rises to 30 v, diode current increases to 380 ma; the resulting larger voltage drop across R_s holds the output voltage change to 0.15 v. Thus the change in output voltage is ±1.7% for ±13% change in input voltage, an improvement of about 8:1.



The value of the series resistor R_s may be changed in order to regulate load currents of 150 to 600 ma. Value is selected to produce diode current of 250 ma when the input voltage is at the center value of 26.5 v.

Regulation is not as good at higher load currents; for example, at 600-ma load current a 2.6% change in load voltage results from input voltage changes of 13%.

Input: 26.5-30 v dc, at 680 ma max.

Output: 11.65 v dc at 300 ma, regulated.

Voltage regulation: ±1.6% change in output voltage for input voltage variation from 26.5-30 v.

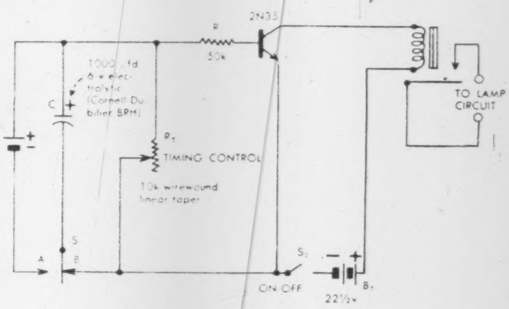
Load regulation: Calculations were made only for constant load conditions.

Source: Hoffman Electronics Corp., Semiconductor Div., 930 Pitner Ave., Evanston, Ill.

TRANSISTOR TIMING CIRCUIT PROVIDES 1-30 SECOND INTERVALS

A relay is held closed by this circuit for a time adjustable over the range of 1 to 30 seconds. Relay contacts can be used to control current to a lamp for timing photographic exposures. Relay used is a Sigma 4F 3000-ohm d-c relay set for 1-ma operation.

Switch S1, a momentary-contact pushbutton type, is normally in position B. To start the timing cycle, S1 is pressed, connecting capacitor C across the 1½-v battery. When S1 is released, the capacitor begins to discharge through timing-control rheostat R2 and the base circuit of the 2N35 transistor. Base current causes collector conduction, closing the relay.


2N35
R
50k
1000 μfd 6 v electrolytic (Cornell Dubilier BRH)
C
+
B
1½ v
+
−
R
TIMING CONTROL
10k wirewound linear taper
S
A
B
S
ON-OFF
− +
B
22½ v
TO LAMP CIRCUIT

Capacitor discharge continues at a rate depending on the setting of timing control R2, and the relay remains closed until the base current has dropped sufficiently. Resistor R1 limits the initial base current to a safe value.

Dial of the timing control can be calibrated with a stop watch or other timer; longer intervals may be obtained by increasing the value of R2.

Power supply: 1½-v d-c and 22½-v d-c; quiescent drain on 22½-v battery is approximately 5 ua.

Source: Booklet, 28 *Uses for Junction Transistors*, Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.

Journal of the SCMA...
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Secretary-Treasurer: *Glen C. Wilson, 10219 Orange Ave., South Gate, California*

Huntington Beach Steam Station

Huntington Beach Steam Station represents several "firsts" for the Southern California Edison Company; these include their first: (1) 200-Mw unit, (2) cross-compound unit, (3) 2400 psig unit, (4) 1050 F superheat steam unit, (5) axial-flow exhaust unit, (6) station to employ demineralized make-up water.

A. L. GUIDERO
Southern California Edison Company

THE initial steam conditions of 2400 psig and 1050 F at the throttle, together with 1000°F reheated steam, six stages of feedwater heating and axial-flow exhaust have been combined to produce an expected station heat rate of about 9064 Btu/Kwh. This heat rate and the 200 Mw output make this unit (Fig. 1) the largest and most efficient in the Edison generating system and (for a time) on the Pacific Coast.

Turbine-Generator

The new unit, manufactured by General Electric Co., consists of a high-pressure element (driving a 3600-rpm generator) and a low-pressure element (driving an 1800-rpm generator). Output is divided about equally between the two generators. This is the first large turbine-generator with axial-flow exhaust to go into service in the United States.

This design has proved to be of great interest to the power plant engineer for two principal reasons: First, an appreciable gain in thermal performance is expected from this type of exhaust; such gain is expected to be in the order of 40 Btu/Kwh and is roughly equivalent to adding another heater to the feedwater heating system. Second, the physical arrangement of the axial-flow exhaust and coupled condenser has proved favorable to a relatively low turbine deck height. Turbine decks of our recent reheat plants featured 26′ turbine decks while Huntington Beach features an 18′ deck. This reduction in deck height permits savings in plant construction cost.

Steam Generator

The steam generator (boiler) was manufactured by Babcock & Wilcox Co. and is rated at 1,560,000 lbs/hr of continuous steam output. Steam leaves the superheater at 1050°F and at such pressure as required to deliver 2400 psig steam at the turbine inlet. Steam exhausted from the high-pressure turbine cylinder is reheated by the boiler to 1000°F before re-entering the turbine.

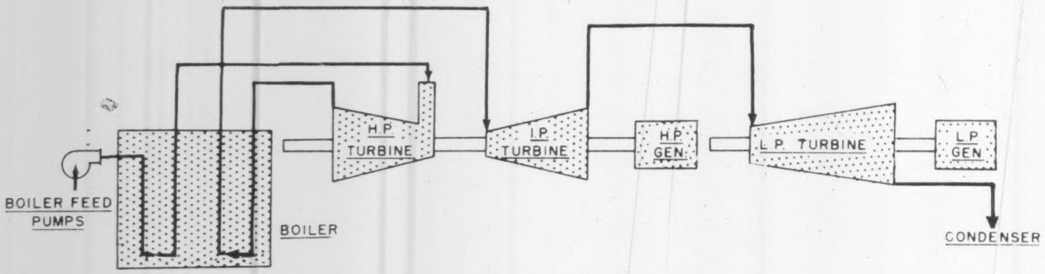

FIG. 1. BASIC UNITS in the Huntington Beach Station. Steam input to H.P. turbine is 1,400,000 lb/hr, 1,050° F, 2400 psig; steam input to I.P. turbine is 1,229,730 lb/hr, 1000°F, 470 psig. H.P. generator (3600 rpm) produces 106,370 kw; L.P. generator (1800 rpm) produces 115,111 kw.

Talk before Southern California Meter Association, Huntington Beach Steam Station plant tour at Villa Marina, June 19, 1958.

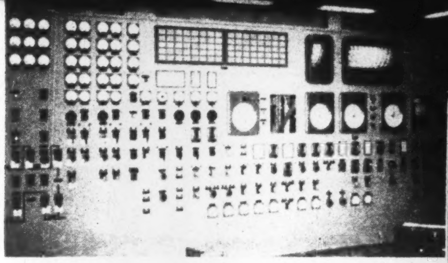

FIG. 2

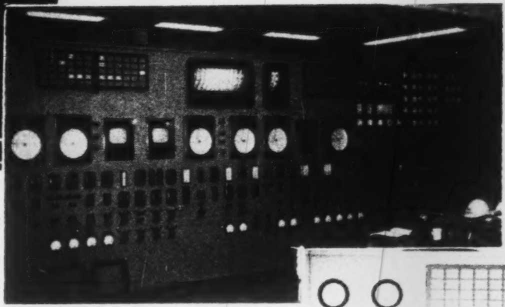

FIG. 3 →

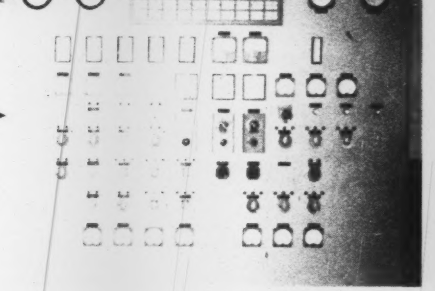

FIG. 4 →

The boiler is described as a radiant-furnace reheat steam generator with pressurized furnace and flue gas recirculation to assist in maintaining rated steam temperatures. Vernier steam temperature control is accomplished by spray attemperation. Prime energy is provided by firing either oil fuel or natural gas or a combination thereof. When firing with oil fuel, this equipment is expected to be better than 88% efficient at rated outputs; when firing with natural gas the efficiency will be somewhat less by virtue of the higher moisture losses associated with gas fuel.

Instrumentation

The most outstanding postwar development in the over-all picture of instruments and controls has been the grouping of this equipment into one room from which virtually all items in the plant are controlled. The most prominent benefits derived from central control are:

1. Improved integration and coordination of over-all plant controls.
2. Improved station thermal economy.
3. Reduction in manpower requirements creates opportunities for experienced operators to advance in rating to central control operators and man new stations which have been developing in rapid sequence.

The control arrangement at Huntington Beach (Figs. 2, 3 and 4) follows what is becoming a conventional pattern for steam station central control rooms. A panel starts with the *boiler* instruments and controls; these are followed by the *turbine* instruments and controls which, in turn, are followed by the *generator* instruments and controls. A separate electrical panel is provided for control of switching the generating units to the system. This panel also includes turbine supervisory instruments. One more panel includes such common station controls and instruments for soot blowers, circulating water, etc.

Feedwater Regulation

Feedwater regulation at Huntington Beach employs Bailey three-element controls (drum level, feedwater flow and steam flow). Changes in the combined intelligence from these signals initiates action to speed or slow the boiler feed pumps through the hydraulic couplings. The feature of flow control by hydraulic coupling is a departure from practice in prior plants where feedwater regulating valves are employed. Problems with high rates of valve wear, together with economics of a high-load-factor high-pressure plant influenced the decision to adopt hydraulic couplings.*

In the three elements of regulation, drum level is sensed in a conventional manner, as is feedwater flow (measured by manometric deflection across a flow nozzle). Steam flow is sensed as a function of turbine first-stage shell pressure, which General Electric has found to exhibit an accurate and linear relationship to steam flow. We will be able to report further on the acceptability of this means of metering steam flow with further experience. If this principle proves satisfactory we can dispense with the cost and questionable accuracy of high-pressure steam-flow nozzles now commonly used in power plants.

Other Plant Controls

The combustion controls, which must control the fuel demands of the boiler over a load range of about 6 to 1, almost, must be able to control fuel and combustion air input when the boiler is firing oil or gas fuel or some combination thereof. Thus fuel flow, air flow and steam flow signals are combined to achieve the fine degree of control necessary in modern steam-generating equipment.

This plant incorporates a full complement of station load level controls, alarms, bearing temperature alarms on all major plant auxiliaries, annunciators, safety trips and devices to assure station output with minimum interruption.

January Meeting: Thursday, the 15th, Rio Hondo Country Club, Downey, California.

Feature: George A. Rutledge, Bristol Co., will present a paper on "Time Sharing Telemetering Installation."

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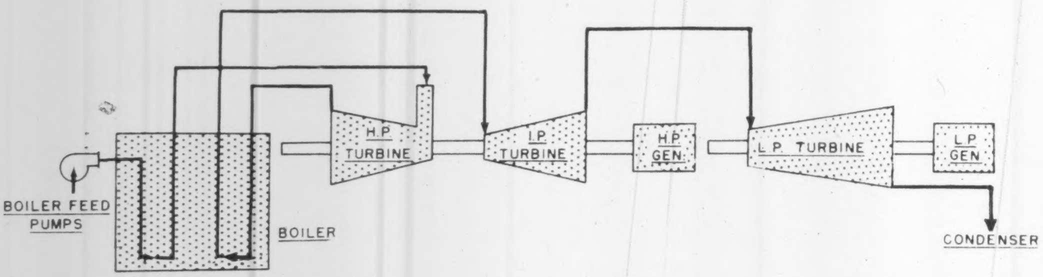

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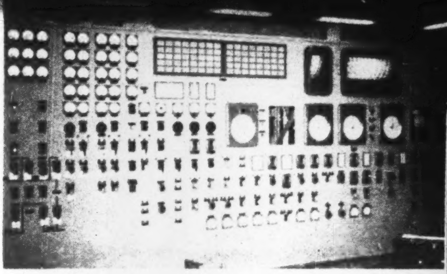

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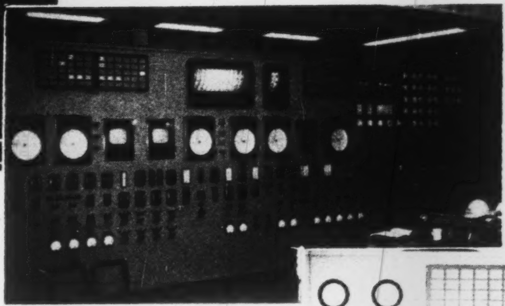
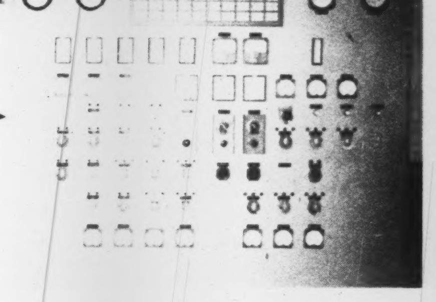


FIG. 3



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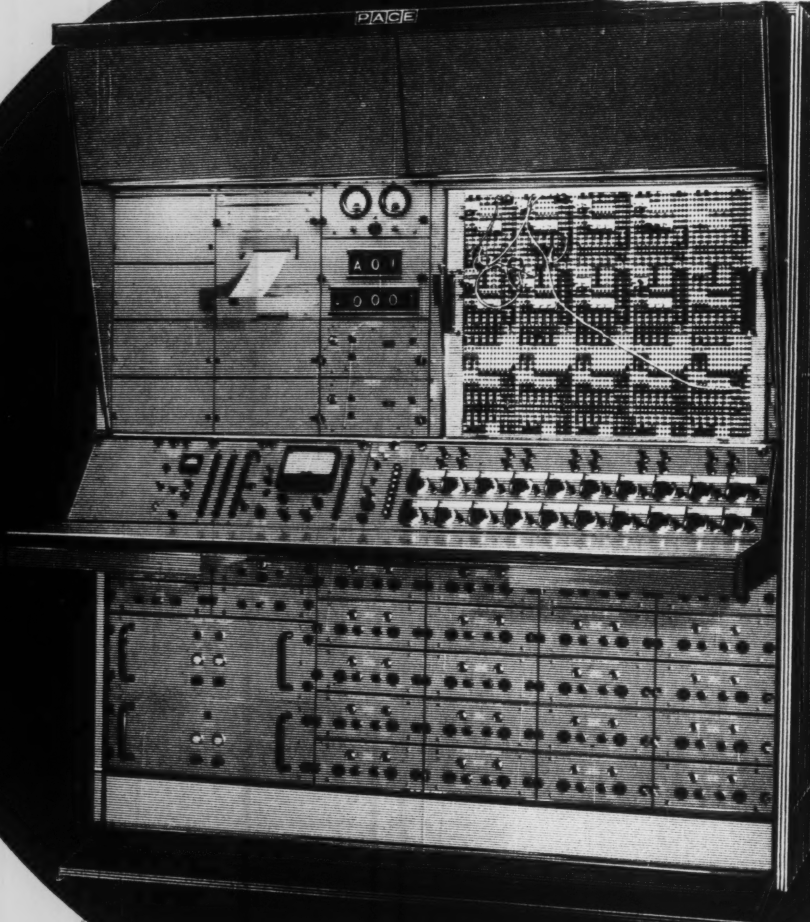

For more information circle 63 on inquiry card.

The SIMULATION COUNCIL *Newsletter*

John H. McLeod, Jr., EDITOR
Suzette McLeod, SECRETARY

8484 LaJolla Shores Drive
LaJolla, Calif.

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Bits

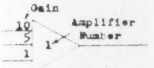
Do you feel the *Newsletter* is good only for light reading—not to be taken seriously? In this issue we offer you some truly weighty material; you will find us almost completely concerned with heavier-than-air craft. Much heavier!

Herewith the program of the Midwestern Simulation Council on September 8th:

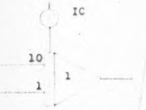
Don Routh, "Simulation of the Suspension System of Large Earth-Moving Equipment by using an Analog Computer"
Robert Kohr, "Simulation of Automobile Suspension and Steering Systems"
Robert Harnett, "Simulation of Landing Gear Vibration"
John Bird, "A Three-Dimensional Tank Simulation"
I. J. Sattinger, "Three-Dimensional Simulation of Vehicle Suspension System"

You'd like to know more? Read PIECES:

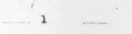
During the Astronautics Western S/C meeting of Sept. 11, *Harold Wasilk* passed out a questionnaire requesting that all present indicate their favored symbols for analog computer components. The illustrations below (somewhat biased by Astro's experience) indicate the result.


Gain
10
5
1
Amplifier Number
1

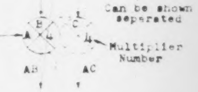
SUMMING AMPLIFIER



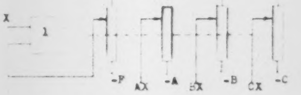
INTEGRATING AMPLIFIER



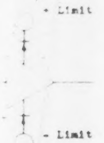
HIGH GAIN AMPLIFIER


B
A
4
C
1
4
Can be shown separated
Multiplier Number
AB
AC

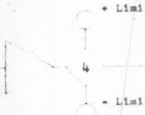
ELECTRONIC MULTIPLIER


X
1
+F
-F
+A
-A
AX
+B
-B
BX
+C
-C
CX

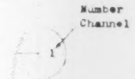
SERVO MULTIPLIER


+ Limit
- Limit

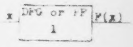
DIODE LIMITED AMPLIFIER


+ Limit
4
- Limit

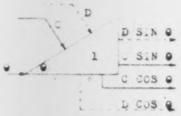
BRIDGE LIMITER


Number
Channel
1

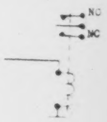
RECORDER


x
DFG or PF
1
F(x)

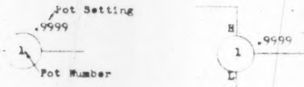
FUNCTION GENERATOR, DIODE OR PHOTOFORMER


D
C
θ
θ
1
D SIN θ
C SIN θ
C COS θ
D COS θ

Rectangular Conversion RESOLVER



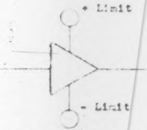
GENERAL PURPOSE RELAY


Pot Setting
.9999
1
Pot Number
H
1
.9999
L

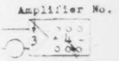
2 - Terminal Pot

3 - Terminal Pot

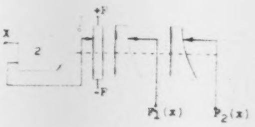
COEFFICIENT POTENTIOMETERS


+ Limit
- Limit

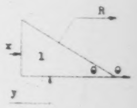
CATHODE FOLLOWER LIMITER


Amplifier No.
3
4
Comparator No.

COMPARATORS


X
2
+F
-F
F1(x)
F2(x)

PADDED POT FUNCTION GENERATOR



Polar Conversion RESOLVER

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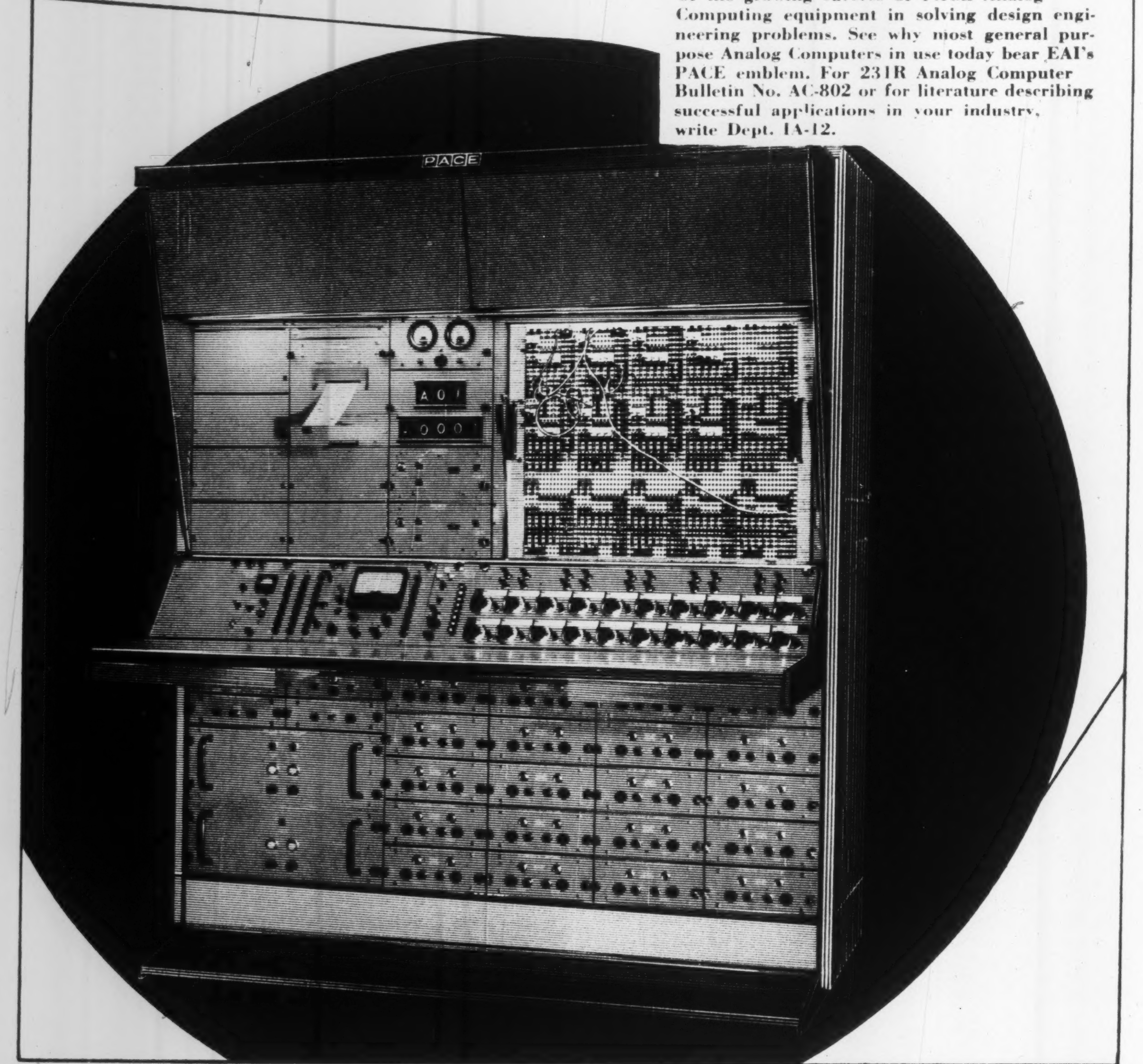

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Bits

Do you feel the *Newsletter* is good only for light reading—not to be taken seriously? In this issue we offer you some truly weighty material; you will find us almost completely concerned with heavier-than-air craft. Much heavier!

Herewith the program of the Midwestern Simulation Council on September 8th:

Don Routh, "Simulation of the Suspension System of Large Earth-Moving Equipment by using an Analog Computer"

Robert Kohr, "Simulation of Automobile Suspension and Steering Systems"

Robert Harnett, "Simulation of Landing Gear Vibration"

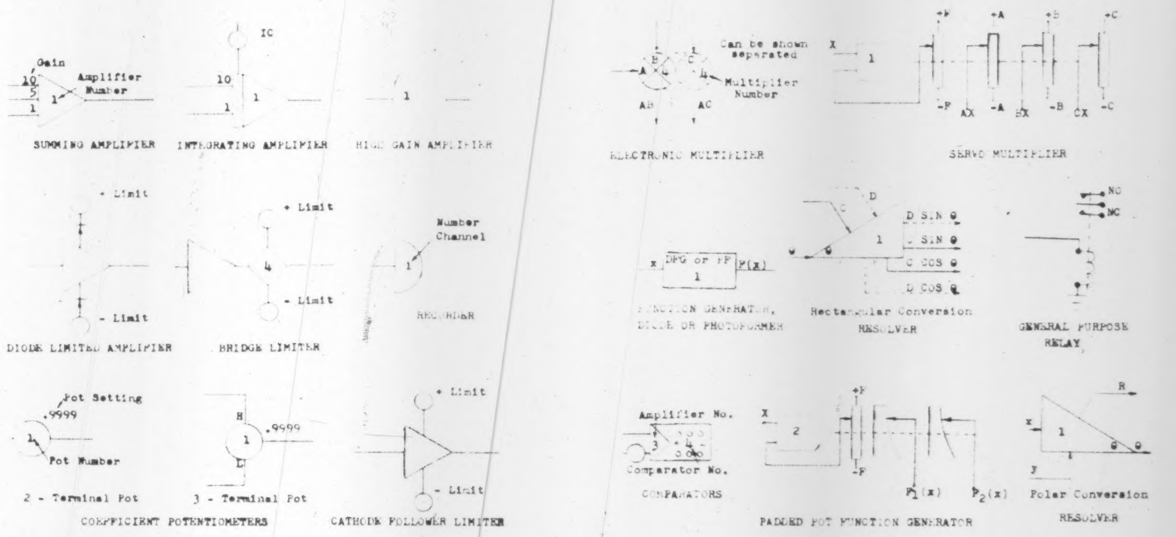
John Bird, "A Three-Dimensional Tank Simulation"

I. J. Sattinger, "Three-Dimensional Simulation of Vehicle Suspension System"

You'd like to know more? Read PIECES:

* * *

During the Astronautics Western S/C meeting of Sept. 11, *Harold Wasilk* passed out a questionnaire requesting that all present indicate their favored symbols for analog computer components. The illustrations below (somewhat biased by Astro's experience) indicate the result.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Polar Conversion RESOLVER

SIMULATION COUNCIL

Pieces

MIDWESTERN S/C MEETING OF 8 SEPTEMBER 1958 ON LAND VEHICLE SIMULATION

About 50 members were present when the Midwestern Simulation Council met at the Caterpillar Tractor Company in Peoria, Illinois to talk about "Land Vehicle Simulation." People who arrived early were conducted on tours of the plant by *Ralph King* and his associates. Compared to the aircraft industry you could say that what they saw was "heavy" industry. Caterpillar earth movers and tractors have such poor lift-to-weight ratios and aerodynamic characteristics that it is doubtful that they will ever get them off the ground!

Warren Jackson (Standard Oil Co. of Ohio, Cleveland) conducted the meeting, his last as Chairman. Warren introduced *Ralph King*, head of the Caterpillar Analog Computer Laboratory, who in turn introduced Mr. *L. A. Blanc;* Mr. Blanc welcomed the group on behalf of Caterpillar and evidently meant it—lunch was on the house!

Routh on Suspension Systems of Earth-Moving Equipment

Don W. Routh (Caterpillar) got the technical ball rolling with a talk "The Simulation of the Suspension Systems of Large Earthmoving Equipment by Using an Analog Computer." He began with a film taken at Caterpillar's Arizona testing grounds which showed tests on track-laying tractors and rubber-tired earth-moving equipment. It was interesting but also a bit weird to see pictures of monster rubber-tired earth-movers galloping down the test road.

For the track-type tractor probably the most severe conditions are encountered in rocky areas. With the total weight of these tractors ranging from about 10,000 to 85,000 pounds, a wide range of forces must be handled.

With the tractor-scraper the most undesirable condition is encountered while travelling over multiple bumps which, properly spaced, excite a severe bounce condition. At the Arizona proving ground 6″ x 6″ wood blocks spaced at the correct (or incorrect!) intervals are used.

The suspension system of the tractor consists mainly of the sprocket, rollers, roller frame, and idler. The idler and sprocket are both mounted so that they are above the ground level; thus the entire tractor weight rests on the rollers. It was decided to study this suspension two-dimensionally by considering it as a damped spring-mass system symmetrical about the longitudinal, vertical plane.

Spring rates were found to be in the order of 400,000 lb-in and up. Under ordinary working conditions the ground is actually softer than this, so that the ground deflects rather than the springs. Because in the computer studies it was necessary to assume infinite hardness of the road surface, it was necessary to run the tractor over bumps on reinforced concrete to obtain good correlation of simulation and test data.

The damping was considered to be of the linear-viscous type. This is certainly not rigorous, but has given good results.

It was necessary to develop a "bump" to simulate an obstacle lying beneath the track which would cause the track links to buckle, forming an inverted V-type ramp. Fortunately it was convenient to produce such a bump in field testing, and not too difficult to generate it on the computer. Since amplifiers were at a premium, it was decided to use function generators for this purpose and switch them to influence each spring in the proper sequence. As the displacement of the bump was symmetrical, it was possible to sweep the function both forward and backward for this purpose.

Another problem in the simulation of wheels and bumps is that of simulating the effect of the wheels leaving the road surface, because it is impossible for the ground to pull down on the wheel. The method chosen to simulate this effect was to limit the sum of the forces to positive values only. Thus, when the sum of the forces approached the negative it was held at zero, and the only force on the mass was that of gravity. However, an error is introduced when the mass comes back down to strike the ground. The amount of the error depends on the ratio of the damping and spring forces. This latter fact allows the error to be minimized until it is possible to ignore it.

This tractor simulation required 46 amplifiers, three function generators, 47 potentiometers, and about 3000 headaches!

The *tractor-scraper problem* is somewhat similar to the tractor problem except that it is broken down into three components: the scraper, the draft frame, and the tractor. The tires at front and rear are directly coupled to the tractor and scraper, and act as springs but not as an unsprung mass.

When starting their investigations Don's group usually strives first to simulate an actual unit. Once they feel the model is a good representation of the actual vehicle, design changes are made with the computer and the results compared to the original model. Showing curves of such a comparison Don asked, "Need I say that this correlation did not come on the first try? In our original attempts we had trouble obtaining the correct ratio between primary and secondary forces, the primary force being defined as the force due to striking the bump and the secondary force that due to the frame's slamming back down after passing over the bump."

It was decided that the trouble must be in the tire spring rate. "In our original model we had assumed a constant spring rate for the tires. Experimental measurements showed, however, that if the tire was placed on a 4″ x 4″ wood block, the spring rate was about 70% of the spring rate measured when the tire was on the ground." It was therefore decided to simulate this by reducing the spring rate whenever the bump was being fed to the tire by reducing the spring deflection.

Don closed by saying "We feel that the analog computer used in the design and development of suspension systems is a very powerful tool, one which should reduce the experimental time spent in prototype development and at the same time give us a better understanding of the physical apparatus."

* * *

Kohr on Automobile Suspension and Steering

Next on the program was *Robert H. Kohr* (Vehicle Dynamics Section, Engineering Mechanics Department of the General Motors Research Staff at Warren, Michigan). Speaking on "Simulation of Automobile Suspension and Steering Systems", Bob explained that in the past, automobile suspension and steering design has proceeded largely on the basis of empirical experience, with specific cut-and-try modifications on

SPEAKING WITH EASE®

An up-to-the-minute report on computer technology prepared by the **Beckman/Berkeley** *engineering staff*

How About an All-electronic Computer?

Marked by a steady shift from mechanical to electronic techniques, the evolution of the analog computer has reached the point where only a few mechanical vestiges remain. These mechanical left-overs (multipliers, resolvers and function generators using servo driven potentiometers) have long appeared to be anachronisms awaiting the development of equivalent electronic apparatus. Now, with recent improvements in electronic non-linear elements it has become practical to obtain an all-electronic computer. The question to be answered by anyone planning an installation is: "Are electronic methods more efficient for my purposes than older servo methods?" Because Beckman/Berkeley designs and sells both types of equipment, our engineers have given considerable thought to the advantages and disadvantages of each. We believe that electronic elements are now generally superior in most applications; however, the choice will depend upon an analysis of requirements for accuracy, speed, maintenance ease and cost. Let's see how recent electronic equipment compares with servo equipment in these respects.

Electronic Techniques Now Most Accurate

A few years ago it was common to use servo multipliers and resolvers for precise computation at low speeds and to reserve electronic devices for fast computation in problems where high accuracy was not essential. This division of labor is no longer realistic. The best electronic multipliers now have a static accuracy of .02% as against .06% for the most precise servo multipliers, and precise electronic resolvers are accurate to approximately .05% in comparison to roughly 1% for servo resolvers.

At high rates of computation electronic multipliers continue to be far more accurate than servos. The fastest servo has 2% error at only 5 cps whereas the slowest EASE electronic multiplier has less than 1% error at 30 cps. Fast servos naturally have poorer static accuracy than the .06% mentioned above.

Comparison of Service Problems

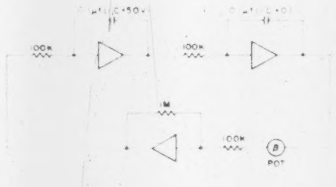
Both servo and electronic equipment present service problems, but of different sorts.

Servo equipment has a well-earned reputation for dependable service. The best precision wire-wound potentiometers are quite durable. Moreover, because servo amplifiers are closed-loop devices, they are not critically dependent on circuit parameters, consequently do not require frequent tube replacement or re-adjustment. On the other hand, under heavy use potentiometers will wear out in 6 months to a year, and replacement is both difficult and expensive. Each new potentiometer will cost up to $900, and equipment may be out of operation several weeks awaiting delivery. When considering maintenance costs, it is also well to remember that all potentiometers in a gang wear simultaneously even when only one or two are actively computing.

Electronic multiplier-resolvers require more frequent attention, but repairs are usually inexpensive and easy to perform. A supply of tubes can be kept on hand and re-adjustment can be performed by anyone who has mastered a "cook-book" procedure.

Correction

In the November issue of "Speaking with EASE," the diagram of a patched-in oscillator for testing phase shift contained typographical errors. The corrected diagram appears below.



Comparative Costs for the Same Operations

In general, servo multipliers and resolvers are most efficient when problems involve a large number of products with a common multiplier of the form XA, XB, XC, etc. or XsinA, XsinB, XsinC, etc. Given the ideal number of such products to utilize full servo capacity, the cost of precision servo equipment can be 20% to 45% less than the cost of electronic equipment for performing the same operations. On the other hand, electronic equipment is most efficient when computations involve independent products of the form XA, YB, etc. or XsinA, YsinB, etc. When problems involve products of this sort, precision servo equipment may cost twice as much as required electronic apparatus. There is a combination of common and independent products at which costs are about the same.

Cost estimates should also give due weight to the greater versatility of electronic multipliers and resolvers. These units are often able to do double duty, thus reducing the cost of an entire installation. For example:

(1) Electronic multipliers will perform as dividers without use of supplementary amplifiers.

(2) An electronic resolver, consisting of a sinusoidal function generator and a separate multiplier, will perform as a straightforward multiplier.

(3) An electronic resolver will generate "sinA" leaving the associated multiplier free to generate an independent product.

Arbitrary Function Generators

The final link in the all-electronic computer is the arbitrary function generator. While servo and electronic methods are too various for detailed consideration here, it can be said that, in general, electronic methods offer far greater accuracy, speed and versatility whereas servos provide a comparatively inexpensive method of generating a severely limited range of functions.

Detailed information on EASE multipliers, resolvers and function generators is available on request.

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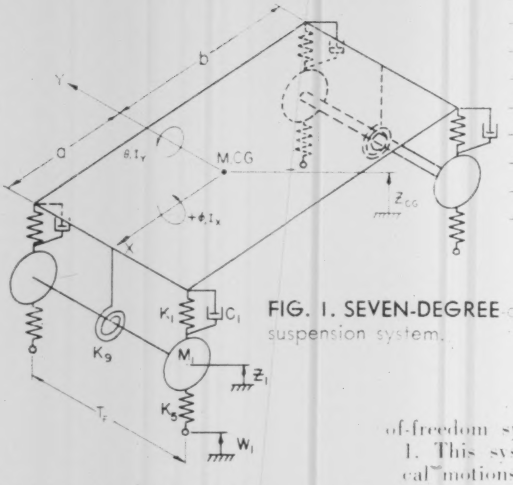

FIG. 1. SEVEN-DEGREE-of-freedom suspension system.

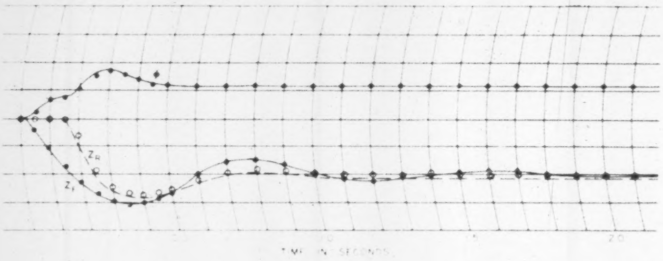

FIG. 2. ANALOG AND DIGITAL solutions of seven-degree-of-freedom system; step input. Dots are digital solution. Z_F and Z_R are body displacements measured at front and rear axles; Φ is the roll angle.

prototype vehicles under the guidance of expert test-driver opinion, and many satisfactory automobiles have been produced by this approach.

However, the general trend toward heavier cars with softer tires and the increasing adoption of power steering and air suspensions call for a complete dynamic analysis of the automobile with a view to gaining a basic understanding of the automobile's behavior on the road.

The use of automatic computers to simulate automobile suspension and steering systems thus becomes necessary to a fuller understanding of the automobile as a dynamic system.

Simulation of the dynamic characteristics of the automobile begins with establishing the automobile's equations of motion. It is possible to break the problem of automobile dynamics into two separate problems: the first involves motion in the plane of symmetry, called longitudinal motion; the second concerns motion out of the plane of symmetry, called lateral motion.

The fore-and-aft motion in the plane of symmetry relates to the acceleration and braking characteristics of the car and is called the "performance" motion. The up-and-down and pitching motions in the plane of symmetry are together considered the "ride" motions, while the three remaining motions (yaw, roll, and sideslip) are associated with steering control and called "handling" motions.

Since the "ride" and "handling" motions are uncoupled, it is possible to simulate them separately. In general, ride motions relate to suspension characteristics, while handling motions relate to steering characteristics.

Recent work in suspension simulation has utilized the seven-degrees-of-freedom system shown in Figure 1. This system considers the vertical motions of all four wheels plus bounce, pitch, and roll of the body by summing the forces on each wheel and summing the forces and torques that act on the body. Solution on an analog computer is quite straightforward. Tire and suspension characteristics are generally nonlinear, so diode function generators are used to simulate them. A complete simulation required 60 amplifiers and as many as 20 non-linear function generators.

Perhaps the most difficult problem in simulating automobile suspension systems lies in providing inputs to the suspension system. For cars with equal front and rear wheel treads, the road input functions for the front and rear wheels on each side are identical, but are displaced with respect to each other by the length of the wheelbase. A general-purpose magnetic tape unit was used to provide the transport delay. The unit contains a modified commercial tape-transport and two magnetic heads. The road displacement signal was generated elsewhere and recorded by the lower head. It was then picked off the tape by the upper head. Tape speed is directly analogous to the car's speed and the spacing between the magnetic heads is analogous to the car's wheelbase. Each head will handle two channels of information so that one channel represents the road function under the left side of the car and the other channel the right.

An analog computer solution of the linear seven-degrees-of-freedom system is given in Figure 2. The corresponding digital check solution is indicated by dots. The input used was a step bump or curb on the left side of the car only. The three traces show the roll response (ϕ), the front end vertical motion (Z_F), and the rear-end vertical motion (Z_R). The car parameters are those of a 1956 Chevrolet travelling at 45 miles per hour, and the simulation was carried out in real time.

Another source of difficulty in simulating automobile suspensions is the lack of detailed data on road profiles. In general, the shortcomings of past methods are that they are tedious and not adaptable to long stretches of road. General Motors is currently exploring another possibility—that of obtaining the vertical accelerations induced in a towed wheel and then integrating the acceleration twice to obtain displacement. Considerable work remains to be done before this system is completely satisfactory, but a number of successful short-time runs have been made.

It should be apparent that even the seven-degrees-of-freedom system is not complete. Other elements should probably enter the simulation, for example:

- Flexibility of the frame-body combination, both in bending and torsion
- Effect of the engine on its mounts
- Non-Linear spring of the seats
- Dynamic characteristics of the passenger

Of these omissions the most important is probably the passenger-seat combination. It appears that any major contribution to the field of automobile ride must come from consideration of the response of humans to vibrations. The question we need answered is: What is it about one car that causes people to say that it rides better than another? The majority of the available data are based on steady-state sinusoidal excitation. Improvements which may well be made would be the use of random inputs rather than sine waves, and the consideration of transient rather than frequency response. Finally, perhaps the power spectra of the acceleration to which the human is subjected may give better results.

A real-time steering simulator has been of material value in

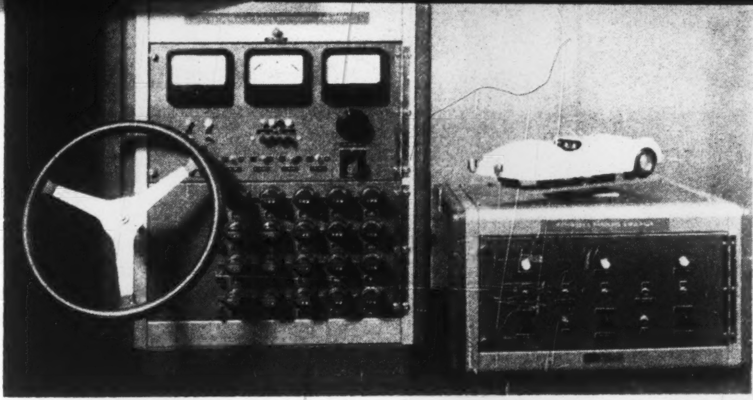

FIG. 3. REAL-TIME automobile-handling simulator.

demonstrating the lateral motions caused by steering inputs. This simulator (Figure 3) is composed of a small special-purpose analog computer which can be "steered" by turning a steering wheel attached to the computer. Movement of the steering wheel causes "steering angle" voltages to be introduced into the analog-computer circuit. The computer then solves the lateral equations of motion of the automobile. The voltages proportional to yaw, roll, and sideslip are applied to a small servo-driven car. This model car can yaw and roll, and demonstrates sideslip by means of a pointer mounted on the car's hood which indicates the direction in which the car is actually going. The computer includes a "skid" meter, a "velocity" meter, and a meter which indicates the applied steer angle. By use of a ganged potentiometer which has an element in the input or feedback of certain of the amplifiers, it is possible to set the forward speed of the car at any point between 30 and 100 miles per hour. Steering-gear ratios can be altered by means of a selector switch. By inserting the proper car parameters on the potentiometers, a wide variety of automobiles can be "driven" on this computer.

As a result of this work, an understanding has been gained of the effects of the various car parameters on the car's lateral response. In addition, a number of general observations have been made:

Yaw and sideslip are strongly coupled, but there is only a weak coupling linking the roll to the yaw and sideslip. However, this weak coupling is often the reason that a particular automobile is stable or unstable, particularly in yaw.

Another interesting result of this work concerns the so-called "oversteer" or "understeer" characteristics. Because of the nature of pneumatic tires, they must run at some slip angle in order to produce side forces. If that angle is greater for the front than the back tires, the path followed by the car curves away from the side force. This is called *understeer.* Conversely, if the slip angle is greater in the rear, the path of the car curves toward the side force, and this is called *oversteer.* The directional stability of an understeering car tends to increase with increasing speed, while the directional stability of the oversteering car tends to decrease. In fact, in the case of oversteer, the "handling" engineers found a critical speed at which the car becomes directionally unstable and at this speed only the most alert action of the driver will keep the car on the road.

The simulations described contain terms from which the "oversteer" and "understeer" characteristics can be computed, and also permit the calculation of a speed at which an "oversteer" car becomes unstable.

Further work in the general area of steering control must include the steering gear, and some consideration must be given to the human operator.* It also appears likely that the tire non-linearities in the near-skid region can be successfully simulated, and that the steering performance of automobiles while accelerating or decelerating can also be evaluated.

Harnett on Landing Gear Vibration

The first afternoon speaker was *Robert T. Harnett,* (Wright Air Development Center, Dayton, Ohio). Bob showed a film on the vibration dynamics of landing gears and said that simulation of the landing-gear vibration problem was started at Wright Field in 1953. The work was originated by Professor *W. J. Moreland,* Chief of the Mechanics Research Branch, Aeronautical Research

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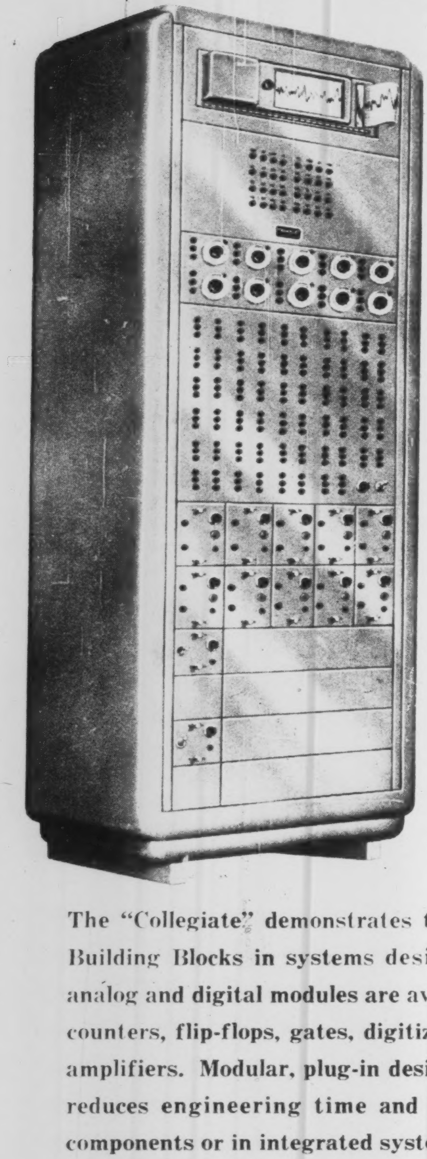

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Laboratory, and the object was to conduct a comprehensive study of an aircraft nose gear system so that stability, or lack of it, could be predicted for any actual system.

The equations used describe a four-degrees-of-freedom system. They are linear, of seventh order, and contain sixteen different parameters which must be specified for each case. In the computer study the following procedure was used to find the effect of aircraft velocity (V) and nose gear damping (C_t), on system stability:

1. Given: The 14 parameters (all except V and C_t) that define a certain case.
2. Select an aircraft velocity (V) and determine those values of damping (C_t) for which the system is "neutrally stable." Usually there are two such values. Between them the system is stable, while it is unstable elsewhere at that velocity.
3. Repeat this for other velocities until a curve like that in Figure 4 can be plotted.

It is apparent that a "hunt-and-try" method would be necessary to find these points of neutral stability, but certain trends could be followed, and the answers came quickly. The problem was originally run on a REAC (Series 100) and later on a GEDA L3. The first cases studied were for the model shown in the movie. Thirty-seven cases of this type were investigated and good agreement was found between computer and test results. Then full-scale tests were conducted at Bendix Products Division, Bendix Aviation Corporation, South Bend, Indiana. Measurements were taken with a B-25 nose gear in a Drop Test Dynamometer Rig and also in the aircraft during taxi tests. Again good agreement was found between computer and test data.

For the past three years all new landing gear designs have been evaluated according to Professor Moreland's method, thus eliminating the dangers that accompany violent shimmy.

* * *

Bird on Tank Simulation

Second speaker of the afternoon was *John W. Bird* (Detroit Tank Arsenal) who spoke on "A Three-Dimensional Tank Simulation." An abstract of John's talk follows:

The Research and Development Division at the Detroit Arsenal is con-

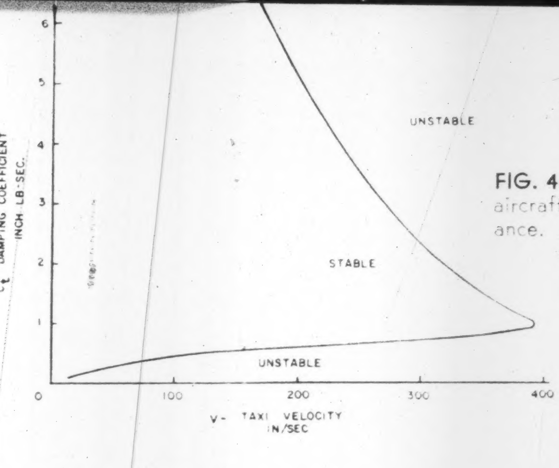

FIG. 4. TYPICAL PLOT of aircraft nose-gear performance.

structing the simulation of a physical system which involves a man riding in a tank and firing the tank gun at a target. The only unsimulated hardware being used is the man, seat, gun control handle, and gun sight. The rest of the physical system is simulated by digital and analog computers, and an integrated fighting compartment simulator is under construction at Lehigh Engineering Associates in Newark, New Jersey.

This paper describes the simulated system by use of block diagrams instead of mathematical equations. The computer simulation is divided into three sections: the road function generator, the vehicle simulation, and the gun control system.

The road function generator is a digital computer programmed by punched paper tape with the accumulator connected to digital-to-analog converters. Each group of two digits of the accumulator is connected to one of three converters, depending on which sign digit is energized. This setup causes four converters at a time to put out voltages representing the vehicle wheel vertical velocities. A total of 12 wheels is thus actuated.

The vehicle simulation was made over from the equations of motion of a jeep devised by the University of Michigan Research Laboratories. The tank hull is assumed to be a free body in space acted upon by the forces exerted by the wheel suspension system and gravity pulling on the hull center of gravity. While the tank is turning a corner, centrifugal force also acts on the vehicle.

The gun control system is simulated by both digital and analog computers. The digital computer brings the gun to a point $2\frac{1}{2}$ degrees from the target, where the analog computer takes over computing the gun to target distance for increased accuracy. The gun-control handle controls the Amplidyne which supplies torque to the gun. The gun rate gyro modifies the control handle signal to keep the gun moving at the called-for velocity. The gyro dynamic characteristics affect this modification. The motor has viscous and coulomb friction and inertia, which modify the motor output torque. Since the gun tends to stay fixed in space unless acted upon by outside forces, the motion of the tank over terrain only affects the gun indirectly by changing the motor inertial and frictional torques.

Sattinger on Vehicle Suspensions

The third and last speaker of the afternoon was *I. J. Sattinger* (Willow Run Laboratories, Ypsilanti, Mich.), who discussed "Three-Dimensional Simulation of Vehicle Suspension Systems." An abstract of his talk is given below:

Beginning in January 1957 the Willow Run Laboratories of the University of Michigan undertook a research program for the Ordnance Tank-Automotive Command to develop methods of simulating vehicle motion in three dimensions. The primary purpose of the three-dimensional simulation is to provide inputs to a vehicle motion simulator being installed at the Detroit Arsenal*, representing the motion of the hull with respect to the earth. This motion can be described in terms of three quantities representing translation, and three quantities representing rotation of the hull.

In the research program the complete set of equations of motion was first written with as few assumptions as could reasonably be made. These equations were then used to prepare a computer diagram to determine the amount of equipment required.

It was found that to represent the motion of a four-wheeled vehicle, the total analog equipment required would consist of something like 160 operational amplifiers, 17 multipliers, and 16 function generators.

For a vehicle with a larger number of wheels correspondingly greater amounts of equipment would be required.

As the next step in the program, a considerably simplified version of the equations was set up on the analog computer, and a number of runs made for various configurations of road obstacles and for various vehicle speeds. This simplified simulation is based on the assumption that pitch and roll angles are limited to 10° or less, that gyroscopic effects and centrifugal force effects were negligible, and that the vehicle ran in a straight line. In essence the six degrees of freedom of the hull were reduced to only three—pitch, bounce and roll.

As a means of determining the adequacy of this simplified simulation, a field test program is being conducted in which an XM-151 (a Ford jeep) was instrumented and run over a set of triangular ramps of various sizes and spacings at various speeds. The field test and computer data then could be compared for what should be identical conditions. This comparison work is still in progress, with final results not yet available. The early indication is that the data compare well in a general way, but that further work will be needed to achieve complete success.

He Went Thataway

Bert Johnson to Central Regional Sales Manager, Electronic Associates Inc., Mount Prospect, Illinois.

Computer Events

Midwestern Simulation Council

Date: 12 January 1959
Place: Allis-Chalmers Manufacturing Co., Milwaukee, Wisc.
Subject: "Application of Analog Components in Control Systems."

High-Speed Computer Conference

Dates: 10-13 February 1959
Place: Louisiana State University, Baton Rouge, Louisiana

Western Joint Computer Conference

Dates: 3-5 March 1959
Place: San Francisco, Calif.

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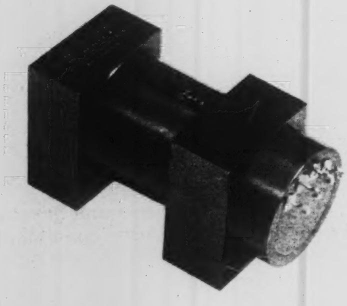
*See the preceding talk, by John Bird.

Magnetic damping in minimum volume



with GLENNITE® AW-1 linear potentiometer accelerometers

For the first time, *magnetic damping in a small, light weight, efficient package!*

Utilizing a new seismic suspension which considerably reduces friction and hysteresis, the GLENNITE AW-1 Series accelerometers have minimum lateral sensitivity and excellent linearity. These instruments meet requirements of MIL-E-5272A, as amended, and may be mounted either parallel to or perpendicular to the sensitive axis.

Available in ranges ±1 to ±10g full scale. And with tap settings as required.

Call in Gulton

Whether you need a single instrument or a complete system, Gulton is capable of meeting all your needs in acceleration measurement and control from transducer to readout equipment. Call in a Gulton Instrumentation Engineer on your next assignment—or on your present one if you have a problem.

GULTON INSTRUMENTATION DIVISION

Gi **Gulton Industries, Inc.**
Metuchen, New Jersey

For more information circle **67** on inquiry card.

new instruments

FOR FURTHER INFORMATION USE THE FREE ORDER CARD ON PAGE 2031

Here are details on the four new electronic process control systems shown first at the ISA Show in September and reported on in short form in our October issue.

FOXBORO CONSOTROL

This new d-c system (10-50 ma, 600 ohms) includes the Series T/600 Transmitters and Converters, Model M/64 Recorders, Model M/65 Indicators, Models M/61 and M/62 Controllers and Control Station (also Panel Combination), and the T/69 Valve Operators.

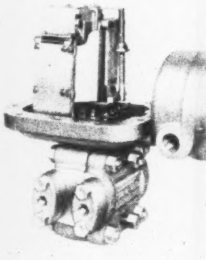
Transmitters are available as force-balance and motion-balance types, and use mag amps (no tubes) and silicon rectifiers. Transmitter output is 0.4 to 2.0 ma with external loads of 10,000 ohms, which signal can be used in low-level logging, etc., or this signal is amplified to 10 to 50 ma (by mag amp). Force-balance types are two-wire and use transistors (no tubes.)

Converters are of the resistance-to-current and emf-to-current type and feature magnetic amplifiers. A Zener-diode regulating circuit provides the constant-voltage cold-junction source (no standard cell or standardization required). Their accuracy is ±0.5% of full scale.

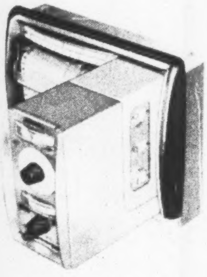
Recorders have 4" chart, need no amplification, have 10-50 ma input, and come in 1-or 2-pen models. Pens are driven by magnetic torque motors.

Indicators are made as precision milliammeters.

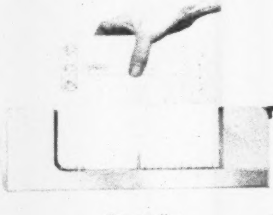
Controllers are self-contained (plug-in) with front adjustments and are independent of the operation of the recorders. No vacuum tubes are used. Inputs are 10 to 50 or 0.4 to 2 ma; output is 10-50 ma. (Amplifica-



D/P Transmitter



Recorder-Controller



Controller

GLASS CYLINDERS RODS • TUBES

CIRCLES & SPECIAL SHAPES

EXPERIMENTAL and PRODUCTION BLOWING

— Your Inquiries Invited —

FABRICATED and CUT to Your SPECIFICATIONS

Glass Tubes and Rods for Scientific Use—Lamps, Furniture, Lighting & Decorative Fixtures—Display Domes—Contract Cutters of Tube and Rod.

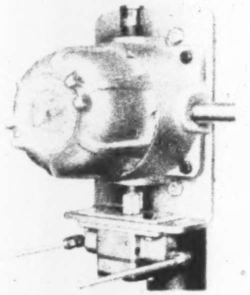
CRYSTAL GLASS TUBE & CYLINDER CO.
7318 South Chicago Ave. • Chicago 19, Ill.

For more information circle **68** on inquiry card.

tion in the universal model M/62 is by transistors. All modes of control are available with the proportional band being extra wide: 2 to 500%.) Flow controllers (M/61) are simplified, use mag-amps, and have proportional-plus-reset action only, with a band of 50-400%.

Control Stations are 3" x 6", and come in individual and multiple-units, or in combination with recorders (9" x 6").

Valve Operators can be electropneumatic or electrohydraulic; latter can be mounted integral with the valve and use the controller's 10-to-50-ma output directly. Force-balance-type electropneumatic converters convert the controller's output to a proportional 3-to-15-psig air signal for operation of pneumatic valves. The converter's torque motor needs no amplification or line power, only 20-psig air supply.

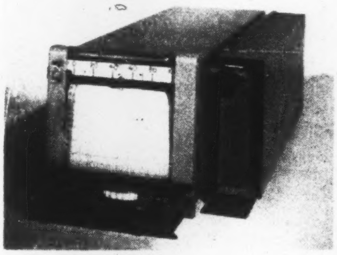


Electro-Pneumatic Converter

(For more information circle **151** on inquiry card.)

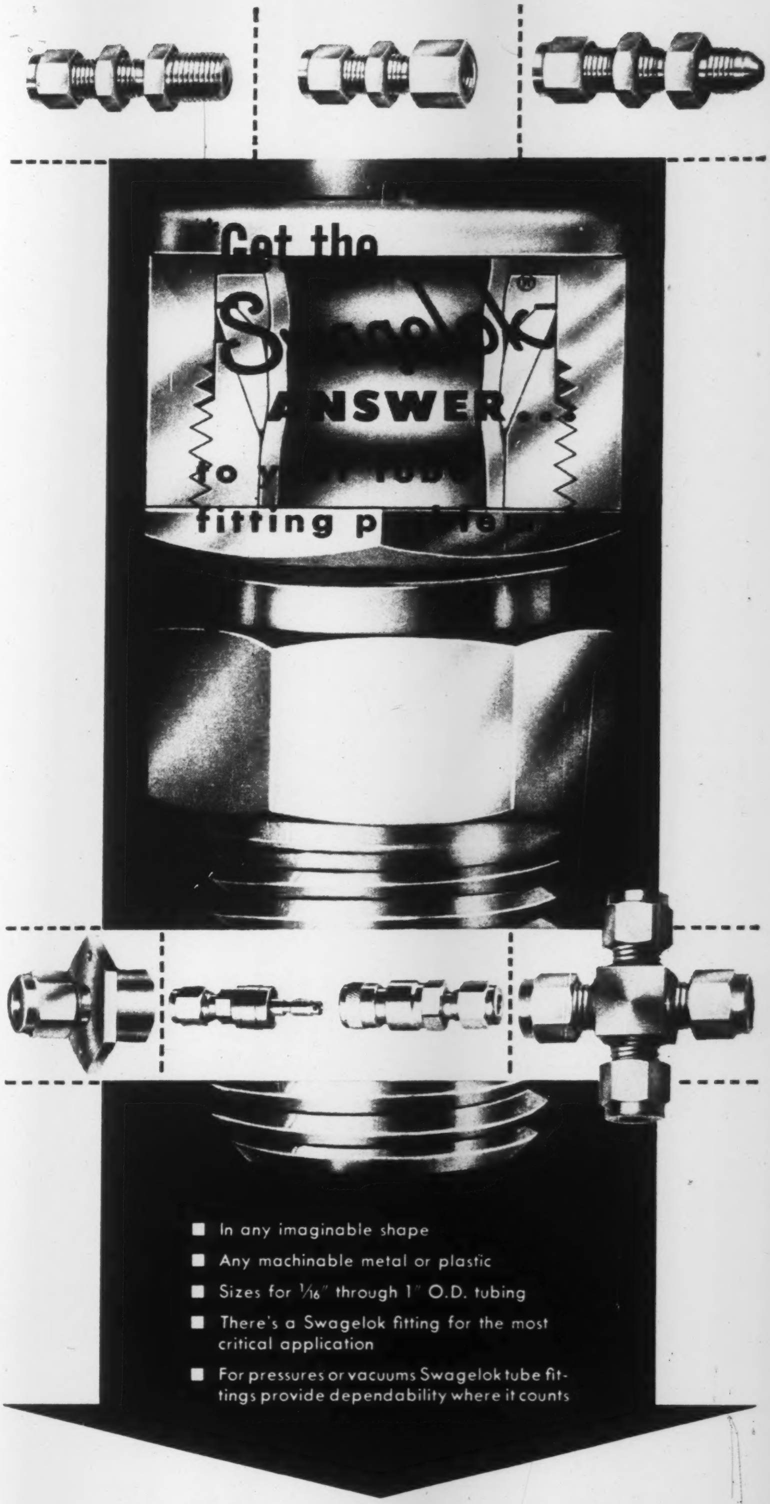
LEEDS & NORTHRUP MINIATURE SYSTEM

The L & N Miniature Electronic Process Control System uses a 1-to-5-ma d-c signal throughout for standard operation, and a 0-to-4-ma signal for data handling and automatic computation. Included are transmitters, recorders, controllers, and electropneumatic converters.



L & N Controller-Recorder

Transmitters are transistorized and of two types: (1) the emf-type transmitter (used for thermocouples, strain gages and other primary elements that have an electric signal) and (2)



- In any imaginable shape
- Any machinable metal or plastic
- Sizes for 1/16" through 1" O.D. tubing
- There's a Swagelok fitting for the most critical application
- For pressures or vacuums Swagelok tube fittings provide dependability where it counts

For complete information and catalog write Dept B 6

CRAWFORD FITTING COMPANY

884 East 140th Street • Cleveland 10, Ohio

For more information circle **69** on inquiry card.

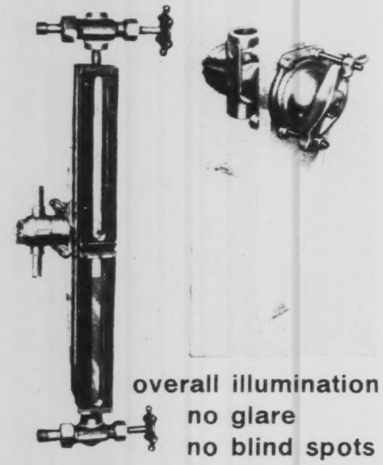
NEW!

PENBERTHY ILLUMINATORS

for Liquid Level Gages

58 WATT 3000 HOUR BULB

accurate readings



overall illumination
no glare
no blind spots

Faster, more accurate liquid level readings are provided by Penberthy's new, improved, explosion-proof, dust-tight illuminators. 58 Watt Bulb (with medium screw base) gives higher light-intensity for 4-times the life of ordinary illuminators. Exclusive rugged aluminum housing over bulb extends bulb life, offers better protection and simplifies relamping. Clear plastic wedge diffuses light over entire length of gage glass.

Illuminators are easily installed on present or new gages. Available in single or double sections, they are used in combination for gages with 3 or more sections. Approved by Underwriters' Laboratories for Class 1, Group C and D hazardous locations.

For further information on Penberthy Illuminators, liquid level gages and valves, write or phone. Ask for Catalog #56.

PENBERTHY

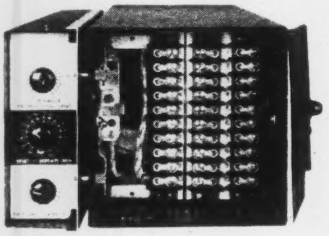
PENBERTHY MANUFACTURING CO.
Division of Buffalo-Eclipse Corporation
1242 Holden Ave., Detroit 2, Michigan

For more information circle **70** on inquiry card.

MINNEAPOLIS-HONEYWELL ELECTRONIC TEL-O-SET

This miniaturized two-wire system (4-20 ma d-c) consists of transmitter, receiver, controller, and final control element, with 20 major types of instruments available. Only two wires are required throughout the system because the 4-20-ma signal serves as both excitation and signal.

Transmitters of the millivolt-to-current type handle signals from thermocouples, resistance thermometers, process stream analyzers, load cells, radiation detectors, tachometers, and preamplifiers for pH or conductivity. Front panel opening permits calibration without removal from mounting rack. Differential-pressure-to-current transmitter, used for flow or liquid-



Controller Features Rear Adjustment

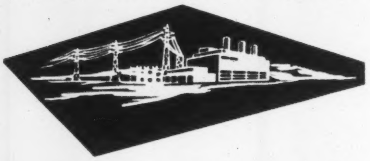
the position-type (for flow, level, and pressure pickups with motion signal).

Recorders have high-torque servos which permit the use of re-transmitting slide-wires and alarms. Chart moves vertically; width is 4". One or 2 pens are available. Amplification is by vacuum tubes.

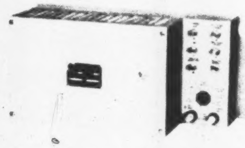
Controllers are essentially transistorized. Control settings are in the rear to eliminate tampering. Ratio and cascade control is obtainable in a single instrument; the latter includes built-in hi and lo limit adjustments of the secondary control point. External load is 500 to 2,500 ohms.

(For more information circle **152** on inquiry card.)

Telemeter
ANY VARIABLE
from Remote Points



MODEL 1025 Transmitter



MODEL 1090 Receiver

Accurate, Fast Acting, Frequency Type Telemeter for Transmission over Wire Lines, Microwave, and Power Line Carrier

Accurate HIGH-SPEED Continuous Telemeter for VOLTS AMPS WATTS VARS ETC.

•

Built-in Self-Calibrating Circuit

•

The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, etc., to 10-30 cps which frequency modulates a built-in audio tone channel. AC 10 to 30 cps or relay outputs are also available. Receiver detects and demodulates transmitted signal, generating a DC mv for operation of recorders or indicating instruments. Up to 45 telemeters can be multiplexed.

Any communication link, including power line carrier, microwave or wire line may be used.

Over-all accuracy is 1% with a response speed of 1 second. Equipment features a built-in calibration circuit for 10% and 90% receiver check, and 10 cps and 30 cps transmitter check.

Any quantity which may be converted into a DC millivoltage or will operate a slidewire may be telemetered.

WE CAN HELP YOU
Our Applications Department is ready to assist you in your control, telemetering or communications problem. Phone DEerfield 4-3100.

Write for Technical and Application Data.

Radio Frequency
LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

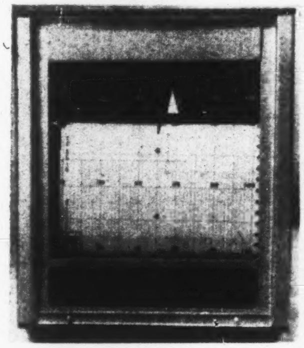
For more information circle **71** on inquiry card.

level applications, has standard bellows meter body mounted at rear with torque tube projecting into case. Rangers are 0" to 20" and 0" to 400" W C.

Pressure Transducers make electric and pneumatic systems compatible.

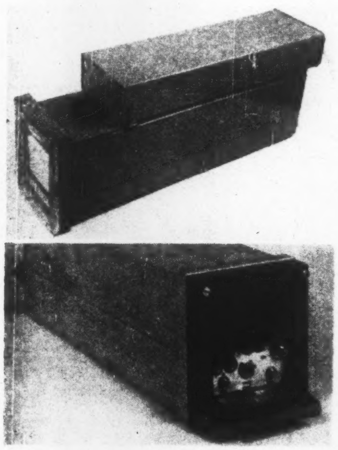
Weather-proof case is available for either unit. Pneumatic signal can be sensed at one location and reproduced five or more miles distant.

Recorder-receiver has visible variable index and evenly graduated scale.



Receiving instrument is made also as indicator.

Controller has back-of-panel mounting, 0-300% proportional band, 0.1-100 rep min, and 0-8 min rate adjustment. Integral assembly permits erection of panels without need for wiring between the two units. Set point and valve current are continuously indicated (with set point adjustment). A switch provides change from automatic to manual control.



Controller Features Rear Adjustment

For more information circle 153 on inquiry card.

CHATILLON
ISO-ELASTIC*
the alloy to
remember when real
PRECISION SPRINGS
are needed

Giants of American instrument industry, including such firms as . . .

- Bulova Research & Development Laboratories, Inc.
- Eclipse Pioneer, Division of Bendix Aviation Corp.
- Federal Telecommunication Laboratories, Inc.
- General Electric Co.
- Sperry Gyroscope Co.

and many others think of CHATILLON, when instrument design calls for the "world's most accurate spring".

CHATILLON . . . the leading manufacturer of precision springs is particularly proud of the improved performance record of instruments using the noteworthy CHATILLON developed temperature-compensated alloy "Iso-Elastic". The hysteresis error of this remarkable spring is less than .05% of deflection. Drift does not exceed .02% of deflection in 5 minutes. These characteristics plus temperature compensation insure the ultimate in precision spring production.

CHATILLON makes Extension, Spiral, Torsion, Compression and Form Springs of Iso-Elastic material, as well as springs of all conventional alloys.

To find out how "the World's Most Accurate Spring" can better your product and for engineering bulletins, write CHATILLON SPRING DIVISION.

*U.S.A. Pat. No. 2174171

JOHN CHATILLON & SONS
85 CLIFF STREET, NEW YORK 38, N.Y.
Manufacturers of Scales, Force Measuring Instruments and Precision Springs Since 1835

For more information circle 72 on inquiry card.

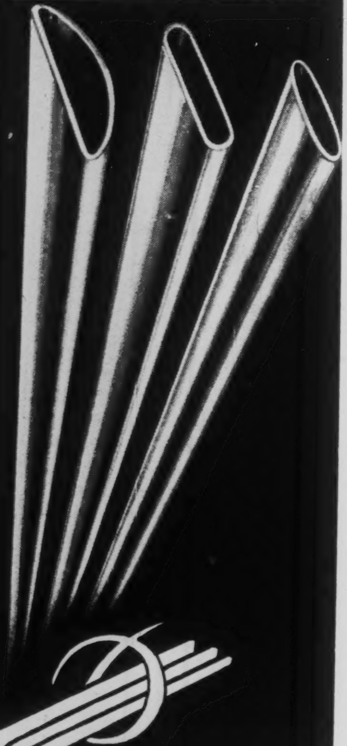
BOURDON TUBING

ACCURATE ONE INCH TO ONE MILE

Constant wall thickness . . . consistent spring properties . . . exact duplication . . . whether a "C", a helix, or a spiral—Precision Bourdon Tubing meets all these requirements. Precision's modern production facilities offer you instrument tubing to meet your most exacting specifications—tubing preformed or straight.

Precision also offers Coaxitube, a metal shielded wire consisting of an inner conductor, insulation and seamless non-ferrous metal tubular shield forming a coaxial pair of conductors. Semi-rigid equivalents to all RG/U cables.

Write for full details on "Precision Tubing For Precision Instruments" to Dept. 3, Precision Tube Corporation, North Wales, Pa.

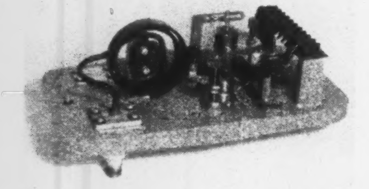


PRECISION TUBE COMPANY

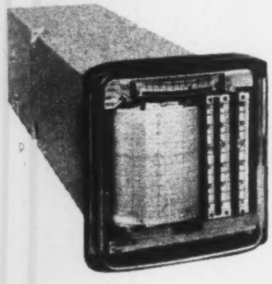
For more information circle **73** on inquiry card.

TAYLOR ELECTRONIC CONTROL SYSTEMS

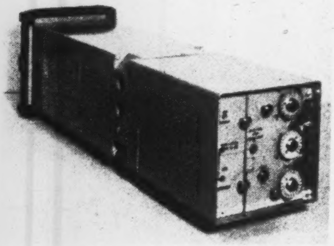
The Taylor Electronic Control System includes both a-c and d-c transmission systems. The a-c system uses 0-to-200-mv transmission signal, the d-c system 1-to-5 ma. In both cases the controller output is 1-to-5 ma d-c. A converter-amplifier feeds the controller in the a-c system. Basic elements include transmitters, recorders, controllers, and valve positioner.



Transmitters in the 700 series are made for temperature, pressure, and flow. Potentiometer Transmitter 700T, in the field for 3 years, fits well into this system. Pressure transmitters use Bourdon springs, mechanically coupled to a simple differential transformer. Amplification at the transmitter is not needed.



Recorders come in one-pen models only (for the time being) and have horizontally-moving 4" chart. Amplification is by transistors operating a null-balance servo motor.

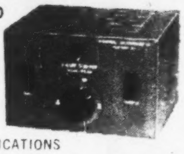


Controllers for a-c and d-c systems are interchangeable when a printed-circuit card is substituted. Two plug-in controller models are made, both using vacuum tubes. The standard model has 0.4 to 200% proportional band with 0.05 to 32 repeats/min reset. The fast reset model has 4 to 2000% proportional band and reset rate of 0.5 to 320 repeats/min. Both have optional derivative time covering

NEW! ELECTRONIC TEST EQUIPMENT

PHASE SHIFTER

Models PS60 & PS400



For measurement and comparison of phase angles or as a secondary phase standard

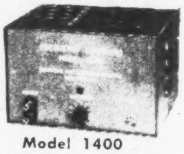
SPECIFICATIONS

RANGE	**0-360°** (continuously variable)
ACCURACY	**± 1 degree** (Higher accuracies available)
FREQUENCY	**60 CPS for PS 60** **400 CPS for PS 400** (other frequencies available)

FREQUENCY STANDARD

A SELF-CONTAINED FORK STABILIZED FREQUENCY SOURCE

- Accurate
- Stable
- Low Distortion
- Variable output voltage
- Compact



Model 1400

SPECIFICATIONS

ACCURACY	**Available to .005%**
DISTORTION	**Less Than 1%**
FREQUENCY	**400 CPS or 1000 CPS** (Other Freq. Avail.)
Dimension	**6x9x6 inches**
Power Supply	**115 volts, 60 CPS**

OTHER MODELS AVAILABLE

MODEL 600 LOW FREQUENCY STANDARD — **DESCRIPTION:** Utilizes scaling circuits to provide tuning fork accuracies at frequencies below the range of precision tuning forks.

AUTOMATIC HI-POT TESTER

Model A

FAST, ACCURATE, DIELECTRIC TESTING FOR MULTI-CONDUCTOR DEVICES

DESCRIPTION: The function of this instrument is to apply in programmed sequence a known voltage between the various conductors under test for a specific period of time and to indicate breakdowns when and where they occur.

SPECIFICATIONS

TEST VOLTAGE	**0-2000 Volts RMS**
TEST TIME	**2-120 seconds**
NUMBER OF TEST TERMINALS	**11**

NULL DETECTOR

Model 60B

A sensitive battery operated null detector ideal for shering bridges or other applications where complete isolation from power lines is desirable.

- Long Battery Life • High Harmonic Rejection • Shielded against external fields

SENSITIVITY: 1 microvolt for 1% deflection

INDUSTRIAL TEST EQUIPMENT CO. ITECO

Write for Catalogs

Reps in Principal Cities

INDUSTRIAL TEST EQUIPMENT CO.
55 E 11th ST · NEW YORK 3 · GR 3-4684

For more information circle **74** on inquiry card.

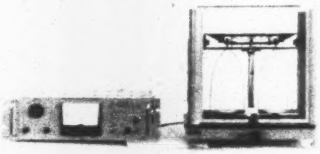
0 to 24 min. Adjustments can be made both from front or rear. A unique diode limiter network in the controller eliminates reset wind-up resulting in improved controllability. Output current is 1-to-5 ma d-c into any 0 to 10,000-ohm actuator load resistance.

Valve positioners of the electro-pneumatic type are force-balanced and use a powerful torque motor.

For more information circle **154** on inquiry card.

AUTOMATIC ANALYTICAL BALANCE

New Model 301A balance features 1-second measurement time and 0.2% accuracy in five automatic ranges from 30 to 3000 milligrams full scale.

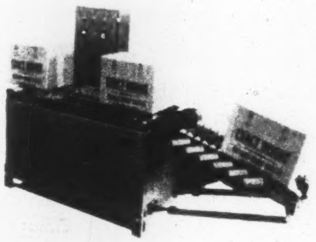


Weight of sample placed on balance is given directly with no mechanical manipulations. Conventional difference methods may be used to extend the range to 200 grams.—*E-H Research Laboratories, 2161 Shattuck Ave., Berkeley 4, Calif.*

For more information circle **155** on inquiry card.

AUTOMATIC CHECKWEIGHER

New Automatic Checkweigher, Selectrol Model 1250, weighs cases, cartons and bags from 20 lb up to 100 lb. Accuracy is 0.1% in this range; speeds up to 30 products per min are



obtainable. Designed for installation in a production line, cases or bags are weighed in motion. The Selectrol is available with underweight and or overweight rejection mechanism or only with electrical signal output. Read-out to printing equipment is available up to 31, for recording 0 to +15, and 0 to −15, by single increments.—*Exact Weight Scale Co., 538 E. Town St., Columbus 15, Ohio*

For more information circle **156** on inquiry card.

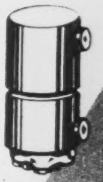
Buyers' Guide Correction

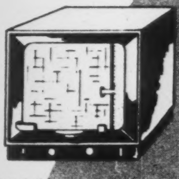
In the Descriptive Directory section of the 1959 *Instruments & Automation Buyers' Guide*, the "see advertisement" line listed the wrong page number for *Dynamic Instrument Company*. It should have read page 150. Please mark this correction in your issue.

check your process instruments on stream with

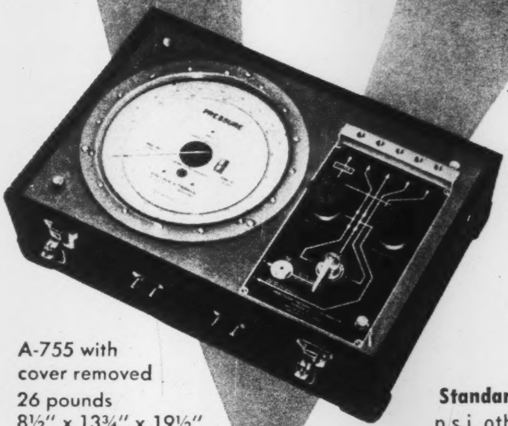
NEW W & T

portable, precision pneumatic calibrator





TRANSMITTER



sensitive to pressure changes as small as 0.01% of full scale

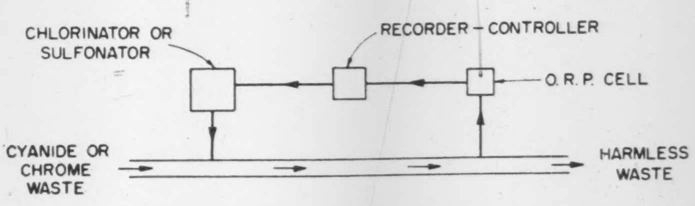
Accuracy: 0.1% of full range

Standard range: —1 to 24 p.s.i. other ranges available

A-755 with cover removed
26 pounds
8½" x 13¾" x 19½"

For complete information, write to Dept. A-124.48

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

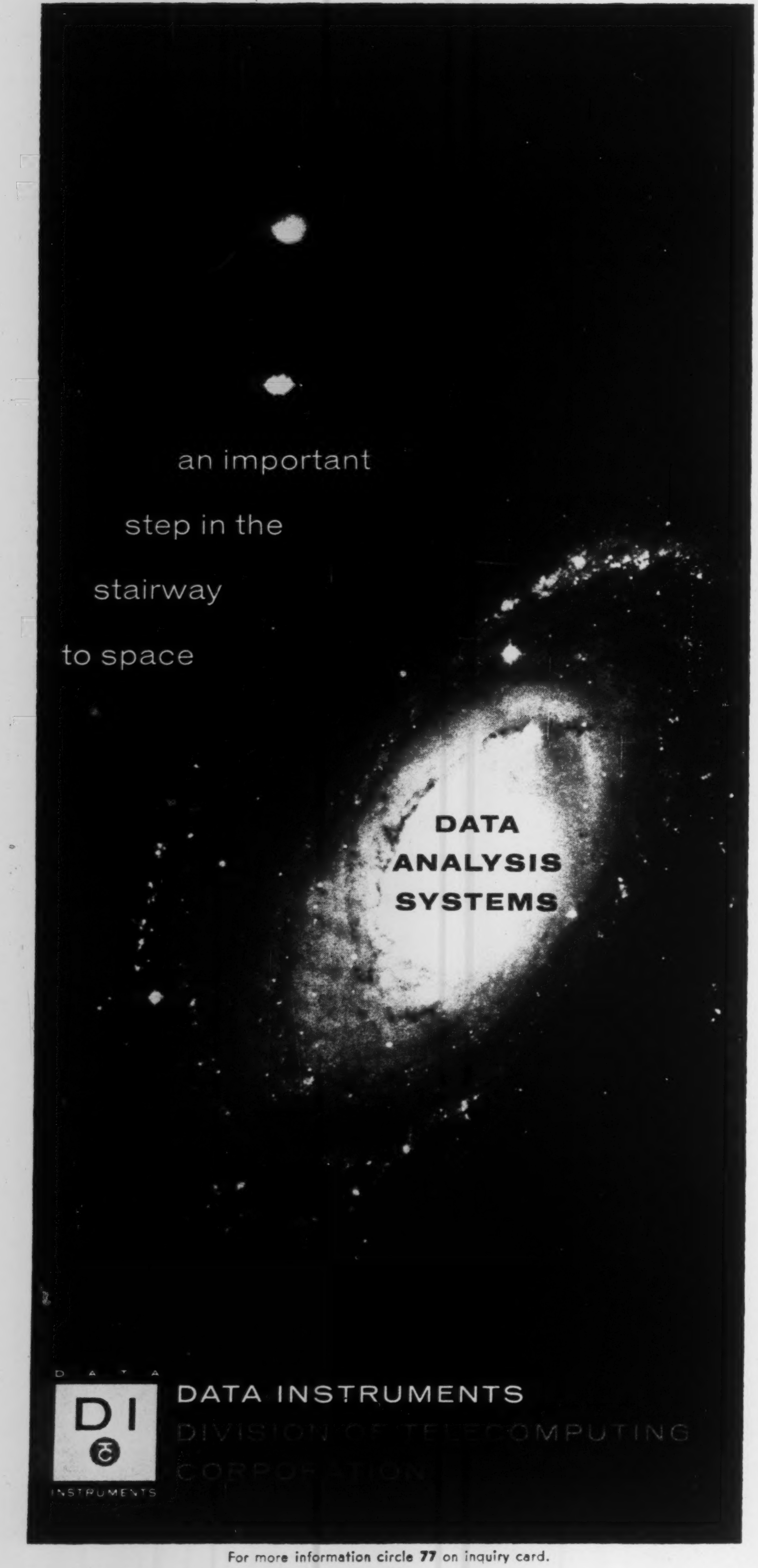


An oxidation-reduction potential cell, monitoring treated waste provides the signal for recording and controlling treatment chemical quantities in a typical W&T waste treatment system.

For Full information on Industrial Waste treatment write Dept. I-66.48

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET BELLEVILLE 9 NEW JERSEY
In Canada, Wallace & Tiernan, Ltd. — Toronto

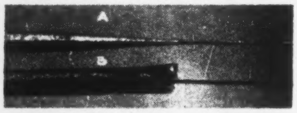
For more information on Pneumatic Calibrator circle **75** on inquiry card.
For more information on Oxidation-reduction potential cell circle **76** on inquiry card.


an important
step in the
stairway
to space
DATA
ANALYSIS
SYSTEMS
DATA
DI
INSTRUMENTS
DATA INSTRUMENTS
DIVISION OF TELECOMPUTING
CORPORATION

For more information circle **77** on inquiry card.

STRAIN GAGE FILAMENT

New one-piece filament in weldable-type resistance-wire Strain Gages has made possible improvements such as

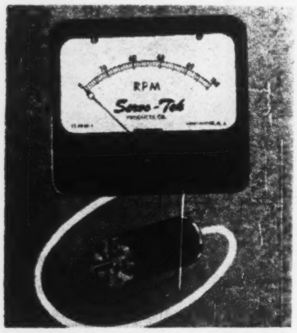


temperature calibration and actual adjustment to temperature sensitivities before mounting. Gages may be used to 1600° F for dynamic strains. —*Micro-Test, Inc., 657 North Spaulding Ave., Los Angeles 36, Calif.*

For more information circle **157** on inquiry card.

SPEED INDICATING SYSTEM

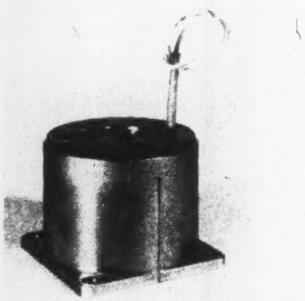
New package uses d-c tachometer generator with 4-½" panel-mounted meter to give full-scale speed indications ranging from 100 to 12,000 rpm. Generator and indicator are connected by a low-voltage cable up to 500 ft in length without affecting the system accuracy. Use of a permanent-magnet generator eliminates the need for batteries, external power, or periodic calibration.—*Servo-Tek Products Co., Inc.* 1086 *Goffle Rd., Hawthorne, N. J.*


RPM
Servo-Tek

For more information circle **158** on inquiry card.

RAPID-RESPONSE SOLENOID

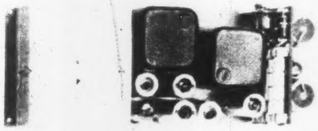
New high-speed solenoid, R.S. 5174, designed to operate with a 24-lb load, starts its 0.020-in stroke at a maximum of 14 msec and completes its travel in less than 20 msec from circuit closing. Voltage rating is 24 vdc at 78°F.—*Telecomputing Corp., Telco Sales Div., 915 North Citrus Ave., Los Angeles 38, Calif.*



For more information circle **159** on inquiry card.

POWER SUPPLY

New Model 137A/PS Power Supply produces a d-c output of 18 watts regulated within 0.5% at + 220v and

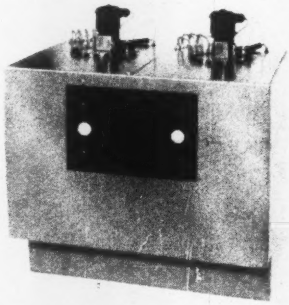


± 220v from any cycle input rating from 60 to 400 cycles.—*Land-Air Inc., subsidiary of California Eastern Aviation, Inc., 7444 W. Wilson Ave., Chicago 31, Ill.*

For more information circle **160** on inquiry card.

CALIBRATING BATH

New double-unit Thermometer-Calibrating Bath, which allows the operator to calibrate a large number of

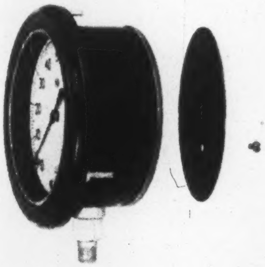


thermometers at two different temperatures at the same time, has two separate completely equipped baths, to develop temperatures ranging from 6°C above room temperature to 260°C, with a constancy of ± 0.2°C.—*American Instrument Co., 8030 Georgia Ave., Silver Spring, Md.*

For more information circle **161** on inquiry card.

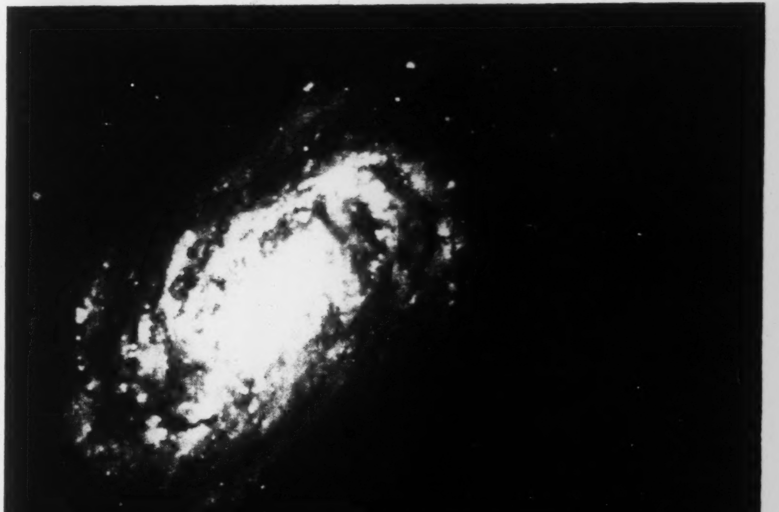
SOLID-FRONT PRESSURE GAGE

New Safe-T-Gage has a solid and integrally-cast metal front plate designed to divert the force of a burst



in a backward direction, away from the operator. Made in 4-½-inch and 6-inch dial sizes; pressures up to 20,000 psig can be measured.—*Helicoid Gage Div., American Chain & Cable Co., Inc., 929 Connecticut Ave., Bridgeport 2, Conn.*

For more information circle **162** on inquiry card.

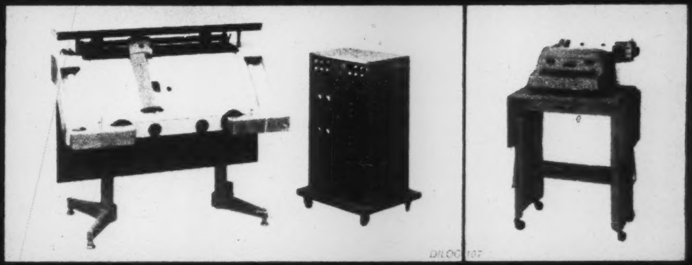


DILOG 107 / data analysis system

For fast, reliable translation of chart readings to real data . . . Automatically prints out data, in digital form, from oscillographic strip charts . . . Eliminates manually reducing and recording data; results in drastic savings of man-hours . . . Particularly valuable for the analysis of strip-chart records.

A completely integrated chart reading system, the *DILOG 107* prepares data in a form acceptable to digital computers or automatically prepares printed reports. Incorporating time-proven DI instruments, the system's modular design permits addition of units as required, to handle your problems of today and *tomorrow*. DI data analysis systems are designed to read and reduce to digital form strip charts and film, as well as for mass spectrogram and photogrammetric reading. Also available are data recording and shaft digitizing systems.

Whatever your application in data analysis, for more information write to: Data Instruments, Telecomputing Corporation, 12838 Saticoy Street, North Hollywood, California.



DILOG 107

DATA INSTRUMENTS

Pioneers in Instrumentation for Data Analysis

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DATA DI TC INSTRUMENTS

For more information circle **77** on inquiry card.

RELIABILITY... THE SOLUTION TO YOUR ELECTRONIC COMPONENT PROBLEMS

Designing reliability into electronic components and instrumentation is Borg Equipment Division's business. Borg's reliable engineering, research and production facilities are at your service for commercial or military projects. Bring your component reliability problems to Borg. You'll enjoy working with our cooperative, creative engineering staff. The result will be a sound, practical and reliable solution at a considerable saving of time and money. Here are just a few of the products manufactured by Borg . . .

- FREQUENCY STANDARDS
- AIRCRAFT INSTRUMENTS
- POTENTIOMETERS
- MULTI-TURN COUNTING DIALS
- FRACTIONAL H. P. MOTORS
- SPECIAL DESIGNS

WRITE FOR COMPLETE ENGINEERING DATA

BORG

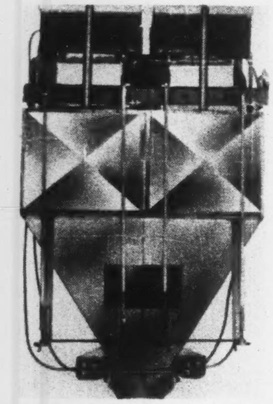
Built by Borg

BORG EQUIPMENT DIVISION
The George W. Borg Corporation
JANESVILLE, WISCONSIN

For more information circle **78** on inquiry card.

HIGH-SPEED BAGGING

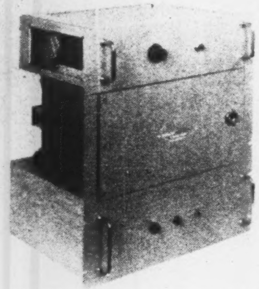
New high-speed Packing Scale, Model 2N18CC, is an automatic duplex filling unit, consisting of two net weigher scales discharging into a common hopper; features high speeds with pin-point accuracy. Unit can be set to make from 25 to 30 dumps per min for package capacities of from 25 to 100 lb each.—*Thayer Scale Corp., Pembroke, Mass.*



For more information circle **163** on inquiry card.

DIGITAL BUFFER STORAGE

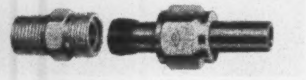
New Core Storage Buffer, Type 1092-BQ8A, stores up to 1092 characters of eight bits each and operates at a 100-kc rate. The unit features interlaced load and unload; internal checking circuits; integral power supply; expandable capacity. Solid-state elements such as ferrite cores, transistors, and diodes, are used throughout.—*Telemeter Magnetics, Inc., 2245 Pontius Ave., Los Angeles 64, Calif.*



For more information circle **164** on inquiry card.

TUBE FITTINGS

New Hi-Seal flareless tube fitting that makes a butt joint, introduced recently in steel and stainless steel, comes now in brass. As it is possible to put the sleeve on in only one direction it secures foolproof assembly.—*Imperial Brass Mfg. Co., 6300 W. Howard St., Chicago 48, Ill.*

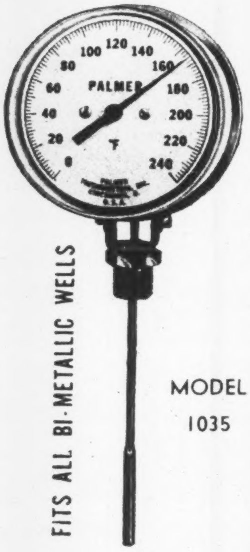


For more information circle **165** on inquiry card.

Outstanding Accuracy

PALMER

Dial Thermometer



FITS ALL BI-METALLIC WELLS

MODEL 1035

Check these functional features

- Direct-drive Bourdon Coil with a filled system for longer lasting accuracy.
- Stem can be placed at any desired angle and case can be rotated to most readable position.
- External calibration for zero setting.
- Unaffected by stem alignment.
- Accurate to one scale division.
- No sticking at any temperature.
- Non-corrosive case.

PALMER

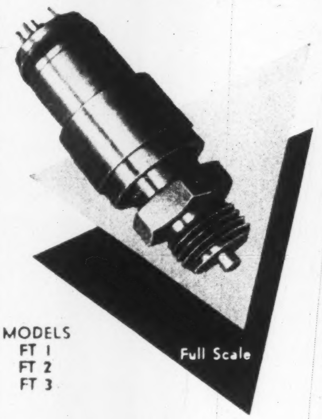
THERMOMETERS, INC.

Mfrs. of Industrial Laboratory,
Recording and Dial Thermometers
2515 Norwood Ave., Cincinnati 12, O.

For more information circle **79** on inquiry card.

Dynisco

FORCE TRANSDUCER



MODELS
FT 1
FT 2
FT 3

Incorporates Unbonded Strain Gauge

HIGHLIGHTS

- MEASURES BOTH TENSILE AND COMPRESSIVE FORCE
- FORCE PROBE DISPLACEMENT LESS THAN 0.00035 INCHES
- OVERALL ACCURACY BETTER THAN 1%
- VERY HIGH NATURAL FREQUENCY
- SMALL SIZE
- WEIGHS ONLY 2 OZ.

FORCE RANGES
0-5 to 0-2000 LBS

REQUEST BULLETIN
NO. 111A

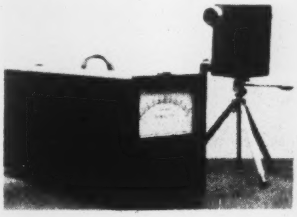
For more information on Dynisco pressure, force, flow, and displacement pickups, write:

DYNAMIC INSTRUMENT CO.
42 Carleton Street
Cambridge 42, Mass.
UN 4-7260

For more information circle 80 on inquiry card.

OPTICAL PYROMETER

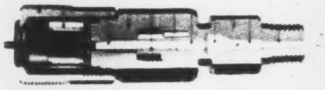
New Shawmeter, an automatic optical pyrometer, measures temperatures of any solid, liquid, or luminous flame in the 1400° to 4000° F range. Emissivity corrections are eliminated because of the instrument's independence of total radiation; and because very little radiant energy is required for operation, temperatures may be measured from a considerable distance. Temperature is indicated on a 7" meter, calibrated in degrees. A 0-to-100-mv output is provided for driving a strip chart recorder or a controller. Speed of response is less than ½ sec.—*Shaw Instrument Corp., 49 Verona Rd., Pittsburgh 21, Pa.*



For more information circle 166 on inquiry card.

THERMOCOUPLE GLAND

New Type "C" Bare Wire Thermocouple Gland provides a positive method for sealing 2 or more bare wires at pressures of 0.005 microns to 20,000 psig, and seals and terminates up to 8 bare wires (24, 20, or 14 gage). Made of Type 303 stainless steel it can be furnished with an open-end tube to provide mechanical protection for the wires in high-velocity or viscous fluids. Sealants are neoprene, Teflon or lava, and insulators are of ceramic.—*Conax Corp., 2300 Walden Ave., Buffalo 25, N. Y.*



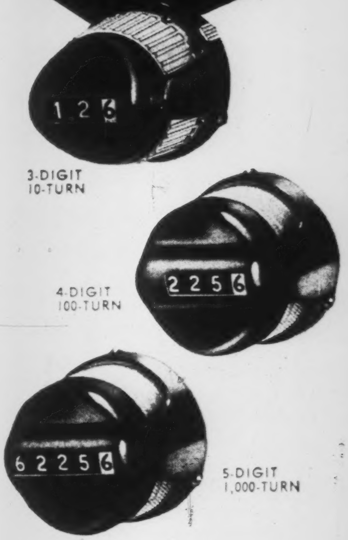
For more information circle 167 on inquiry card.

TAPE READER

New Accessory PR-2 is a photoelectric tape reader that permits any external numeric code punched on 5-, 6- or 7-channel tape to be read into the G-15 Computer. New Accessory CA-2 permits standard 80-column cards, punched in conventional numeric or alphanumeric codes, to be processed by the G-15 at high speed, and the high speed tabulation of numeric or alphanumeric printed copy. Information may be read or punched at the rate of 100 cards per min.—*Bendix Aviation Corp., Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.*

For more information circle 168 on inquiry card.

EASIEST TO READ DIALS EVER DEVELOPED



BORG DIRECT-READING MICRODIALS

Inline digital presentation is the easiest, most accurate way to read numbers! Take advantage of it with Borg Direct-Reading Microdials. Glance at the dial . . . there's your reading . . . jot it down. It's that easy! Available in 3, 4 and 5-digit models. Also available . . . light-weight, 3-digit model 1309 for use where weight is a problem. Write for complete data.

ASK FOR CATALOG BED-A90

Built by Borg

BORG

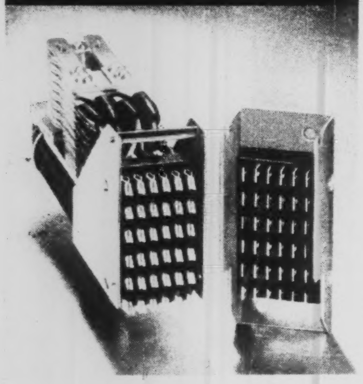
MICROPOTS
MICRODIALS
MOTORS

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

For more information circle 81 on inquiry card.

STROMBERG-CARLSON

Type "A" Relays with Plug-in mountings



For fast, easy removal and replacement you can get Stromberg-Carlson Type "A" Relays with *plug-in mountings*.

The Stromberg-Carlson Plug (illustrated above) automatically locks the relay in place and guarantees a low-resistance connection between plug and socket. Its 36 terminals provide enough connections for practically all relay applications. Coils and contacts are wired to terminals as your needs dictate. Contacts can be furnished in silver, palladium, gold alloy or palladium-silver alloy.

Spring combinations possible with this assembly are 17 Form A or Form B; 10 Form C or Form D.

Also available in an "A" Relay is a plug used with commercial radio type sockets. It can mount relays with 8, 9, 12 or 20 connections.

For technical details and ordering information, send for Bulletin T-5000R, available on request. Write to:

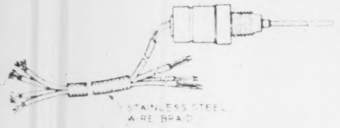
S-C
STROMBERG-CARLSON

STROMBERG-CARLSON
A DIVISION OF GENERAL DYNAMICS CORPORATION
TELECOMMUNICATION INDUSTRIAL SALES
113 Carlson Road, Rochester 3, N. Y.
Electronic and communication products for home, industry and defense

For more information circle **82** on inquiry card.

HIGH-PRESSURE THERMOCOUPLE

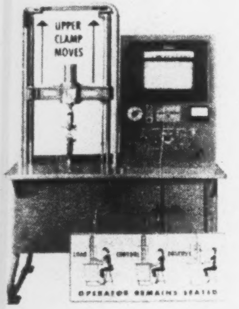
New Armorox thermocouple for temperatures up to 2000°F at pressures up to 50,000 psig is metal-sheathed ceramic-insulated. Sheathing is available in stainless steel and Inconel. Thermocouples are available in Chromel-Alumel, iron-constantan, copper-constantan, and other materials.—*The Bristol Co., Waterbury 20, Conn.*



For more information circle **169** on inquiry card.

ELONGATION TESTERS

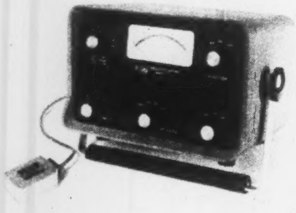
New Model CRE Tensile Elongation Tester, provides a constant rate of extension of speciment by upward moving crosshead. Capacities are from 0-0.05 lb to 0-1,000 lb or 0-25 grams to 0-500 kgs, tensile.—*Scott Testers, Inc., 45 Blackstone St., Providence, R. I.*



For more information circle **170** on inquiry card.

VIBRATION METER

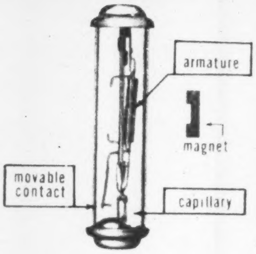
New Model T-1 Vibration Meter for use in conjunction with the TD-Series Vibration Pickups for accurate measurement of velocity, displacement amplitude, and acceleration has battery-powered transistor circuitry.—*Southwestern Industrial Electronics Co., 2831 S. Post Oak Rd., Houston, Texas*



For more information circle **171** on inquiry card.

NEW miniature encapsulated

"MAGNETIC" MERCURY SWITCH



Actual Size

CAPILLARY TYPE MAGNET OPERATED MERCURY SWITCHES

Moveable contact in the hermetically sealed switch makes contact by penetrating opening in the capillary tube (see illustration). Capillary tube is positioned so as to be supplied by the mercury in the well.

VERY LITTLE POWER REQUIRED TO OPERATE SWITCH

Adaptable to applications where a mechanical movement of approximately 0.007 (minimum) with a force of 2 grams is available to move the permanent magnet. Can be operated by small DC electromagnets for incorporation in electric or electronic equipment.

HIGH SPEED OPERATION

Speeds of 400 cycles per minute (at maximum rated load) are obtainable. Higher speeds are possible depending upon load characteristics.

VARIABLE MOUNTING ANGLE

Operation is possible even if switch is tilted as much as 45° from vertical position.

ELECTRICAL CONNECTIONS

Electrical connections to switch are made through the metallic-end caps, eliminating lead wires attached directly to the switch. They are however, available with lead wires of various lengths.

ELECTRICAL CAPACITY

Type 6-81 normally open and Type 6-83 normally closed.

A.C. 115V., 0.3A.; D.C. 115V., 0.15A.

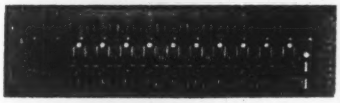
Write for Bulletin 6-81

THE MERCOID CORPORATION
4201 Belmont Ave., Chicago 41, Ill.

For more information circle **83** on inquiry card.

ELECTRONIC COMMUTATOR

New solid-state high-speed Electronic Commutator commutates either a-c or d-c signals to a voltage-to-digital converter, or the output of a digital-to-voltage converter into a number of channels. A maximum of 1000 channels of information, at rates of up to 100,000 samples per sec, can be handled.—*Packard-Bell Electronics Corp., Technical Products Div., 12333 W. Olympic Blvd., Los Angeles 64, Calif.*



For more information circle **172** on inquiry card

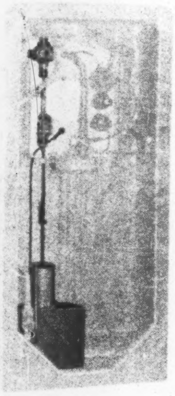
FORCE CALIBRATION

New completely-transistorized electronic system, powered by six conventional flashlight batteries, is designed for the calibration of force-measurement systems. The force is applied to a load ring which has a differential transformer attached to its internal bosses. Ring deflection is sensed by the differential transformer and transmitted electrically to a null-balance instrument. Portable and accurate to 0.1% it has a sensitivity up to 20 microamps for 0.0001" of ring deflection.—*Morehouse Machine Co., 1742 Sixth Ave., York, Penna.*

For more information circle **173** on inquiry card

V-NOTCH POSITIONER

New pneumatic V-notch Positioner, designed for use with company's V-notch Chlorinators, converts 3-to-15-psig signals from any standard pneumatic transmitter to a mechanical movement which positions the V-notch variable-orifice providing a simple way for remote-manual, program, step-rate, or automatic-flow-proportional chlorinator feed-rate control.—*Wallace & Tiernan Inc., 25 Main St., Belleville 9, N. J.*



For more information circle **174** on inquiry card

HEISE GAUGES

Conquest of the Sky

Heise gauges used by research engineers in the development of modern turbo-jet engines provide the reliability, correlation and repeatability necessary to scientific progress.

Actual operating conditions are reproduced in the Cox Test Stand built by Commercial Research Laboratories to test for optimum efficiency of jet fuel nozzles.

The six Heise gauges incorporated in the test stand feature in the vital and exacting performance which this instrument must accomplish.

Higher air speeds, rates of climb and economic fuel consumption, factors which every day reach and surpass new levels of efficiency, are made possible by the continuing efforts of research men equipped with today's most accurate instruments.

Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"-12"-16"

Prices from $166.75

DELIVERY WITHIN 30 DAYS.

HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **84** on inquiry card.

PRECISION

defined by the dictionary
. . . . "the quality or state of being precise; accuracy; mechanical exactness."

defined by an instrument maker . . .

Swiss American

JEWEL BEARINGS

Sapphire and Ruby Precision Jewel Bearings

FEATURE
- exact tolerances
- high shock resistance
- low friction coefficient

FOR
- INSTRUMENTS
- CLOCKS
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Individually Set To Order. Mass Produced For Industrial Requirements.

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SWISS AMERICAN JEWEL BEARINGS CO.
46 Cherry Lane, Floral Park, New York

ONE OF THE LARGEST FACTORIES OF ITS KIND IN THE WORLD

For more information circle 85 on inquiry card.

HARDNESS TESTING

SCLEROSCOPE
FOR TESTING THE HARDNESS OF METALS. PIONEER AMERICAN HARDNESS STANDARD. OVER 40,000 IN USE.

DUROMETER
FOR TESTING THE HARDNESS OF RUBBER & RUBBER-LIKE MATERIALS (ASTM D676) (ASTM D1484)

SHORE INSTRUMENT & MFG. CO., INC.
90-35 VAN WYCK EXP.
JAMAICA 35, N. Y.

For more information circle 86 on inquiry card.

Flow Visualization Instrumentation

Schlieren Systems
Shadowgraphs
Interferometers
Wind Tunnel Optics
Mountings & Piers
Packaged Systems

Catalog upon request

John Unertl Optical Co.
3551-3555 East Street
Pittsburgh 14, Penna.

For more information circle 87 on inquiry card.

DELAY GENERATOR

New Model 218A Digital Delay Generator producing two accurately controlled time intervals is particularly useful in calibrating timing circuits in radar systems, oscilloscopes

and marker generators; in timing responses from drum storage systems of computers; and in the precision pulse code modulation of control carriers. Range is digitally adjustable in 1-usec steps from 1 to 10,000.—*Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.*

For more information circle 175 on inquiry card.

INPUT-OUTPUT EQUIPMENT

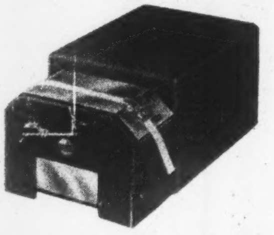
New high-speed Input-Output System, (optional equipment for the LGP-30 electronic computer) is available as a combination high-speed punched-paper-tape Reader and

Punch (Model 342, shown at left) or as a Reader alone (Model 341). The photo-electric reader is capable of reading punched paper tape at a rate of 200 characters per sec. The punch operates at a speed of 20 characters per sec.—*Data Processing Div., Royal McBee Corp., Westchester Ave., Port Chester, N. Y.*

For more information circle 176 on inquiry card.

TAPE READER, TAPE PUNCH

New Model 28, Type LBXD, Tape Reader (illustrated) features 100 words-per-minute operation. It translates code of perforated tape into electrical impulses for sequential or for

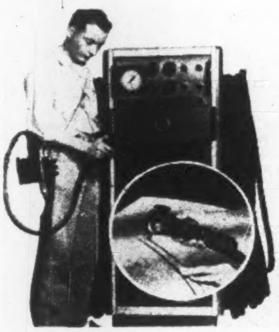


parallel-wire transmission; or receives electrical impulses from external parallel-wire source and converts these impulses for sequential transmission. ★New Model 28, Type LPR, Tape Punch receives incoming sequential signals and translates them into perforated code combinations in tape; types corresponding characters on the tape; and provides facility for parallel-wire output of incoming signals for control of external equipment.—2 brochures contain details.—*Teletype Corp., Dept. SP-2, 4100 Fullerton, Chicago 39, Ill.*

For more information circle **177** on inquiry card.

PORTABLE WELDING GUN

New Model 4032 for rapid spotwelding of thermocouple junctions and similar light assemblies employs ignitron power control circuits for precise control of weld current.—*Research, Inc., 115 N. Buchanan, Hopkins, Minn.*



For more information circle **178** on inquiry card.

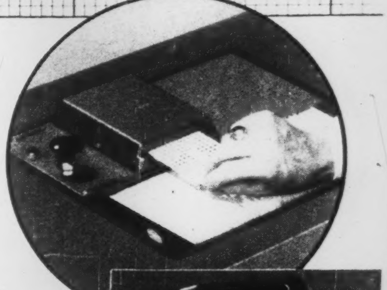
FREQUENCY CONVERTERS

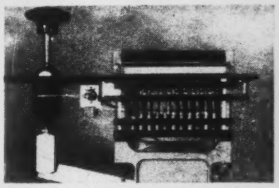
New modular Model-4000-Series Frequency Converters afford simple conversion of any model to single, two- or three-phase operation for range from 100 va to 3 kva by addition of modular power units, output transformers, and power amplifiers. Ideally suited for inertial guidance systems and other applications where variable frequencies between 50 and 4000 cps are required. High-voltage power supply module uses silicon-diode rectifiers and delivers 700 vdc at ½ amp. By various series and parallel connections it can deliver 700, 1400, 2100 or 2800 vdc with ½, 1, 1½, 2, 2½, and 3 amps.—*Tel-Instrument Electronics Corp., Dept. T2 728 Garden St., Carlstadt, N. J.*

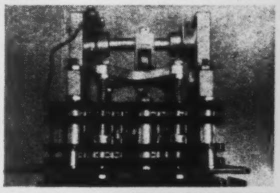
For more information circle **179** on inquiry card.

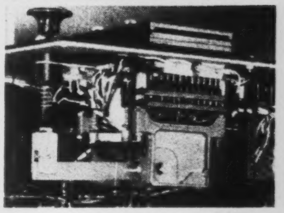
NEW, Automatic Card Programmed Switch

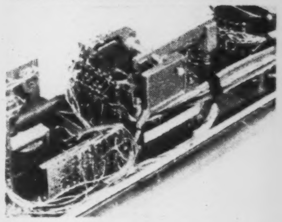
Card programmed, automatic multiple switching is the most practical method for handling complex data in automatic inspection, production control and computer work. The reliability and flexibility of the CARDMATIC design has been thoroughly application proven in complicated test equipment uses.











Versatile
A selected code card will actuate all desired contacts simultaneously—up to 3-trillion variables accommodated automatically. Or, switch can be manually operated with complete safety to mechanism and operator.

Safe—Foolproof
Design is based on the principle that the absence of a hole in the code card closes a switch contact. If switch is accidently actuated without a card, no contact will be made.

Reliable
187 single pole, single throw floating contacts, of self-cleaning, wiping type, have relatively high current carrying capacity (10 amps.) and unusually low contact-to-pin resistance (.00025 ohms). Rugged in design, units have been use-tested to over 150,000 operations without failure.

Flexible
Basically a 3″ x 5″ sandwich design. Top plate accommodates up to approximately 60 individual contacts inviting use of contact strips to alleviate limitations due to wire size. All 187 contacts are available for individual connection on the bottom plate.

Rugged
A spring loaded cam arrangement with momentary control solenoid provides actuation with unusual simplicity. Heavy cast and machined parts allow use of husky operating torque (approx. 15 lbs. . . . 50 contacts simultaneously) for heavy contact pressures with resultant low contact resistance and positive operation. Switch jamming is virtually eliminated and proper card position is assured through a positive alignment feature.

Proven in Application
A typical use in complicated electronic equipment occupies minimum space (approximately 7″ x 7½″ x 5″, 5 lbs.) Terminal strips provide neatness of access and mounting for standard electronic components. Basic switch is $125. Special insulation, wiring and tailoring to specification is available as extra.

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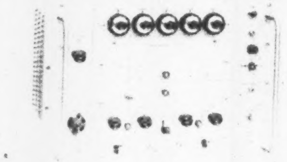
DELAY GENERATOR

New Model 218A Digital Delay Generator producing two accurately controlled time intervals is particularly useful in calibrating timing circuits in radar systems, oscilloscopes



and marker generators; in timing responses from drum storage systems of computers; and in the precision pulse code modulation of control carriers. Range is digitally adjustable in 1-usec steps from 1 to 10,000.—*Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.*

For more information circle **175** on inquiry card.

INPUT-OUTPUT EQUIPMENT

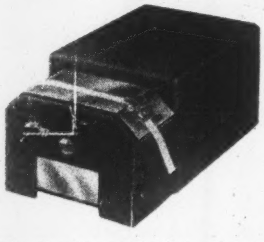
New high-speed Input-Output System, (optional equipment for the LGP-30 electronic computer) is available as a combination high-speed punched-paper-tape Reader and

Punch (Model 342, shown at left) or as a Reader alone (Model 341). The photo-electric reader is capable of reading punched paper tape at a rate of 200 characters per sec. The punch operates at a speed of 20 characters per sec.—*Data Processing Div., Royal McBee Corp., Westchester Ave., Port Chester, N. Y.*

For more information circle **176** on inquiry card.

TAPE READER, TAPE PUNCH

New Model 28, Type LBXD, Tape Reader (illustrated) features 100 words-per-minute operation. It translates code of perforated tape into electrical impulses for sequential or for

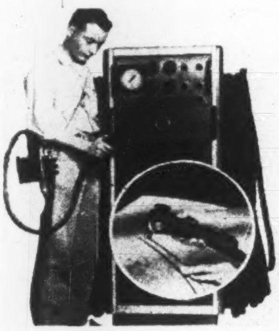


parallel-wire transmission; or receives electrical impulses from external parallel-wire source and converts these impulses for sequential transmission. ★New Model 28, Type LPR, Tape Punch receives incoming sequential signals and translates them into perforated code combinations in tape; types corresponding characters on the tape; and provides facility for parallel-wire output of incoming signals for control of external equipment.—2 brochures contain details.—*Teletype Corp., Dept. SP-2, 4100 Fullerton, Chicago 39, Ill.*

For more information circle **177** on inquiry card.

PORTABLE WELDING GUN

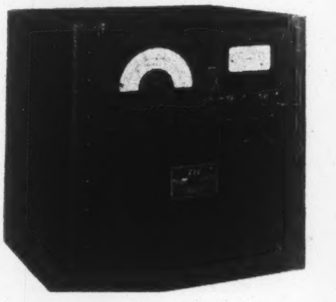
New Model 4032 for rapid spotwelding of thermocouple junctions and similar light assemblies employs ignitron power control circuits for precise control of weld current.—*Research, Inc., 115 N. Buchanan, Hopkins, Minn.*



For more information circle **178** on inquiry card.

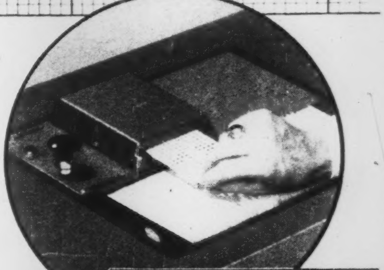
FREQUENCY CONVERTERS

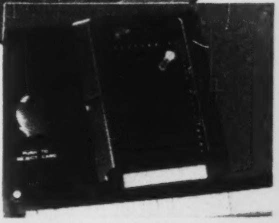
New modular Model-4000-Series Frequency Converters afford simple conversion of any model to single, two- or three-phase operation for range from 100 va to 3 kva by addition of modular power units, output transformers, and power amplifiers.

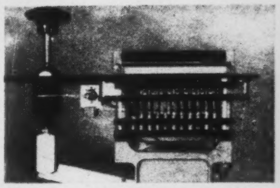


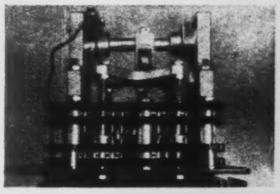
Ideally suited for inertial guidance systems and other applications where variable frequencies between 50 and 4000 cps are required. High-voltage power supply module uses silicon-diode rectifiers and delivers 700 vdc at ½ amp. By various series and parallel connections it can deliver 700, 1400, 2100 or 2800 vdc with ½, 1, 1½, 2, 2½, and 3 amps.—*Tel-Instrument Electronics Corp., Dept. T2 728 Garden St., Carlstadt, N. J.*

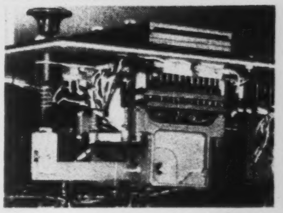
For more information circle **179** on inquiry card.

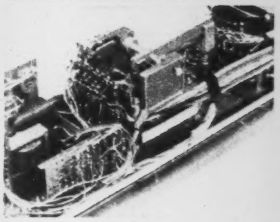












NEW, Automatic Card Programmed Switch

Card programmed, automatic multiple switching is the most practical method for handling complex data in automatic inspection, production control and computer work. The reliability and flexibility of the CARDMATIC design has been thoroughly application proven in complicated test equipment uses.

Versatile

A selected code card will actuate all desired contacts simultaneously—up to 3-trillion variables accommodated automatically. Or, switch can be manually operated with complete safety to mechanism and operator.

Safe—Foolproof

Design is based on the principle that the absence of a hole in the code card closes a switch contact. If switch is accidently actuated without a card, no contact will be made.

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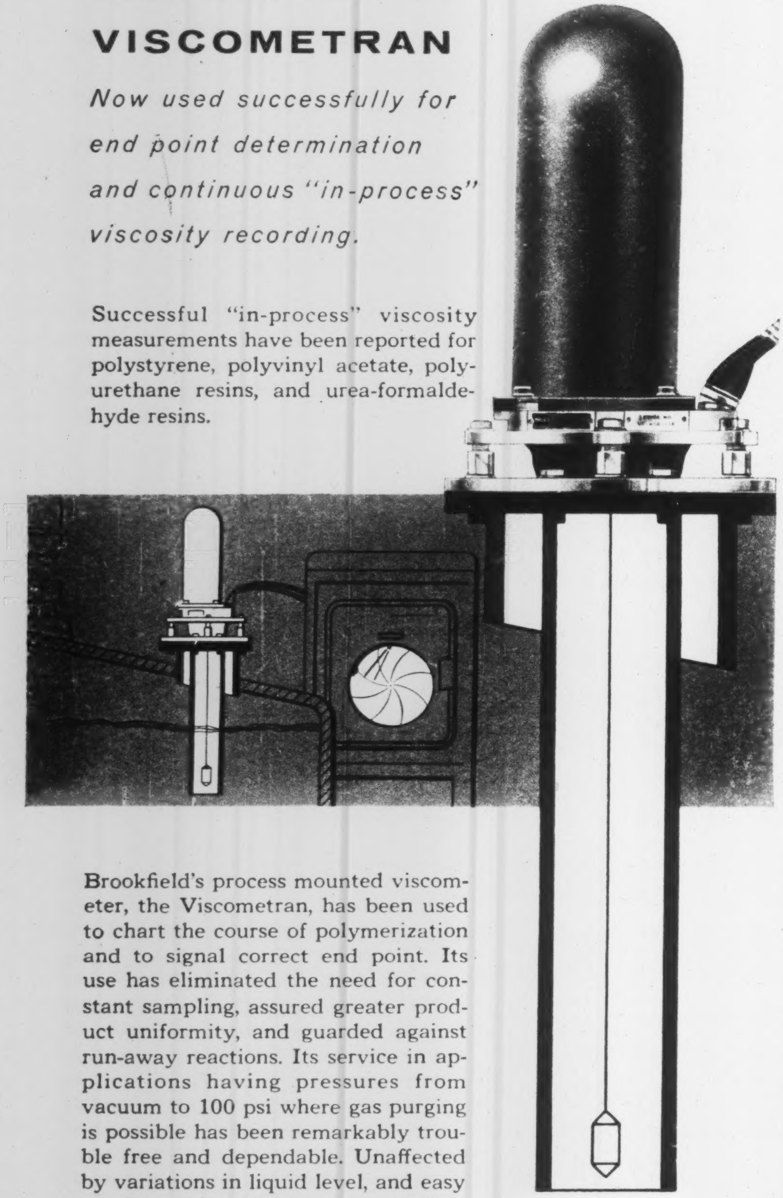
POLYMERIZATION NEWS!

BROOKFIELD VISCOMETRAN

Now used successfully for end point determination and continuous "in-process" viscosity recording.

Successful "in-process" viscosity measurements have been reported for polystyrene, polyvinyl acetate, polyurethane resins, and urea-formaldehyde resins.



Brookfield's process mounted viscometer, the Viscometran, has been used to chart the course of polymerization and to signal correct end point. Its use has eliminated the need for constant sampling, assured greater product uniformity, and guarded against run-away reactions. Its service in applications having pressures from vacuum to 100 psi where gas purging is possible has been remarkably trouble free and dependable. Unaffected by variations in liquid level, and easy to clean, the Viscometran continuously and accurately senses viscosity — a variable that can very well be fundamental in your process.

For new application data sheet write or wire:

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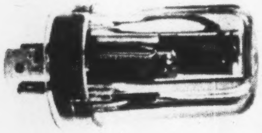
For more information circle **89** on inquiry card.

NEW INSTRUMENTS

LIGHTING CONTROL

New photoelectric control features a single-throw integrating relay and a light-sensitive photo cell which close

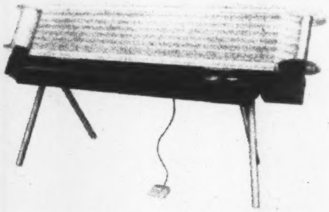


and open circuits at pre-determined natural light levels. Operating levels can be set within 1 to 6 ft-c range. *Precision Magnetic Controls, Inc., 34 Cottage Pl., Ridgewood, N. J.*

For more information circle **180** on inquiry card.

OSCILLOGRAM SCANNER

New Model S-10 scans oscillogram strips up to 1,000 feet in length, on 66-in illuminated scanning surface. Record speed can be adjusted to a

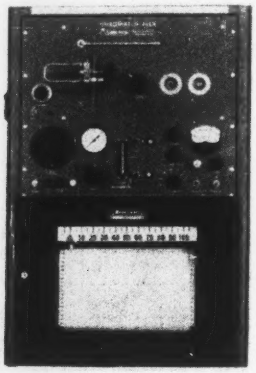


maximum of 100 fpm. Several reading heads, yielding digital or analog outputs are available for the evaluation of presented data.—*Gerber Scientific Instrument Co., 89 Spruce St., Hartford, Conn.*

For more information circle **181** on inquiry card.

GAS CHROMATOGRAPH

New gas chromatograph analyzer Model 11 Chromat-O-Flex, has dual column switching with automatic backflushing, reproducible volume

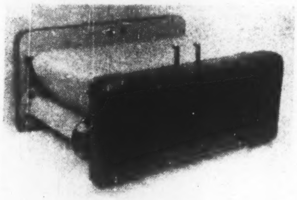


gas sample valve, and automatic electronic temperature control. The detector uses filament or thermistor elements, providing high sensitivity. Recorder has 1 mv full scale.—*Loe Engineering Co., 237 North Fair Oaks, Pasadena, Calif.*

For more information circle **182** on inquiry card.

OSCILLOGRAPH EDITOR

New editing device offers a high-speed simple method of viewing oscillograph trace data paper strip

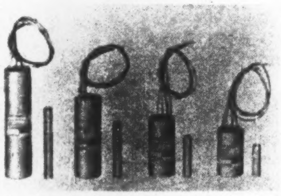


charts of commercial types to 12" width, and rolls through 6" dia. Dual drive unit provides constant speed at infinitely variable settings to a maximum of 200 fpm.—*Fourdee, Inc., P.O. Box 6006, Orlando, Fla.*

For more information circle **183** on inquiry card.

DIFFERENTIAL TRANSFORMER

New Single-Ended Linear Variable Differential Transformer, Series ES-L, has null position at the end and

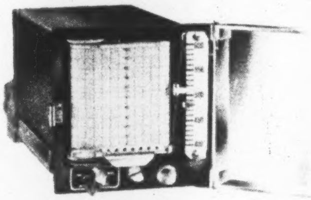


a full linear range. Nominal frequency range is 60 to 10,000 cps.—*Schaevitz Engineering, Route 130 & Schaevitz Blvd., Pennsauken, N. J.*

For more information circle **184** on inquiry card.

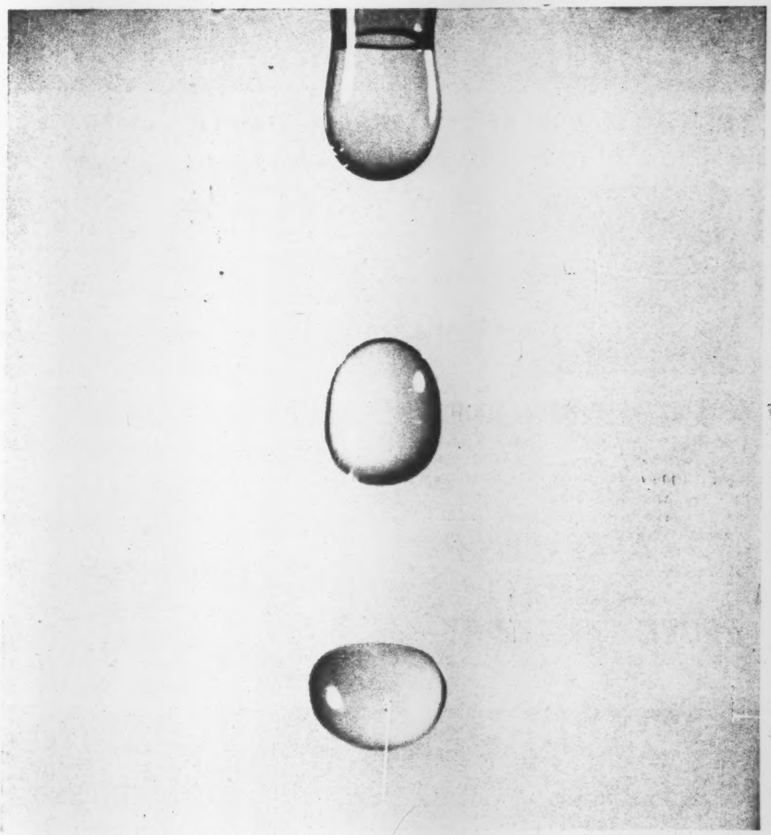
COMPUTER CONTROL STATIONS

New control stations of the Metagraphic type for use with process computer systems receive a 3-15 psi pneumatic signal from the computer. One type has a four-position switch for manual, automatic, or computer



control of the process; the fourth "seal" position allows for "bumpless" transfer between manual and automatic. The other station has a two-position transfer switch for manual or computer control of the process. When on computer control, the control valve is operated directly by the output signal from the computer. Both stations are self-contained and fit into a 4-$\frac{3}{16}$" square panel output. —*The Bristol Co., Waterbury 20, Conn.*

For more information circle **185** on inquiry card.



Photographer Bernard Hoffman uses a tiny droplet of water, forming and falling, to illustrate time sequence.

Controlling Time in Fluid Engineering

Even in simple hydrodynamic situations like the one pictured above, time sequence is measured in micro-seconds. More often than not, other factors—such as pressure, volume and flow—all tend to complicate fluid time control. That's where the engineering leadership of S. Morgan Smith can help you most.

SMS Rotovalves, for example, will give you the closest control of closing time . . . as quick as one second or as slow as needed. Their fast initial shut-off limits reversal of flow, and closure is positive and drop-tight. Rotovalves are easier to operate, requiring less power for mechanical or electrical operation, and their full line opening means less head loss and lower pumping costs.

SMS offers you a complete line of standard Rotovalves, Ball Valves and R-S Butterfly Valves, as well as special application engineering help. To obtain full information, call our nearest representative, or write S. Morgan Smith Company, York, Penna.

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For more information circle **90** on inquiry card.

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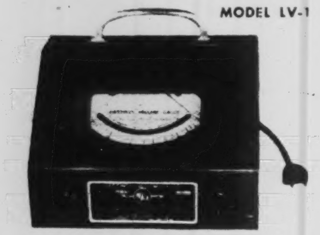

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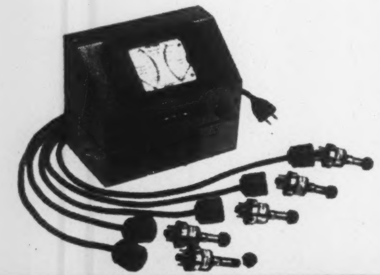
- Matched Gauge Tubes
- No Outgassing Or System Contamination

NEW MODEL LV-1. Measures 0-100 micron Hg. Single meter; large 4" scale indicates vacuum directly without adjustments. Internal voltage regulator takes care of fluctuations in line voltage. Ideal for Industrial Installations. Also available in 0-1000 micron and 0 1-20 mm Hg. ranges.

MODEL GV-3 VACUUM GAUGE

(Shown at right with optional 5-position switching attachment) Range from 0-1000 microns Hg. Manual current set and additional milliampere scale allow adjustment for use in presence of gases other than air, for leak detection, and for specialized laboratory use.



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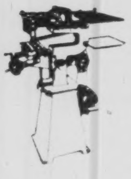

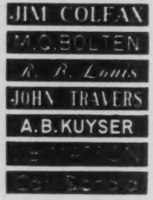

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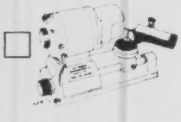

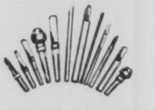

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For more information circle 93 on inquiry card.

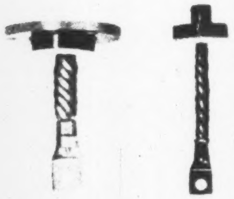
AUTOMATED ANALYSIS

New AutoAnalyzer, a system for continuous, automatic chemical analysis, in laboratory or plant, detects trace materials down to parts per billion with an accuracy of 1%.—*Technicon Controls, Inc., Chauncey, N. Y.*

For more information circle 186 on inquiry card.

POWER RECTIFIERS

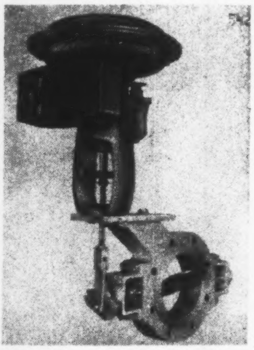
New streamlined Flatline series of Power Rectifiers has current ratings from 20 to 200 amps and a peak inverse voltage range from 50 to 300 v. Flush or stud-base mounting is available in either positive or negative base polarity.—*Sarkes Tarzian, Inc., Rectifier Div.,* 415 *North College Ave., Bloomington, Ind.*



For more information circle 187 on inquiry card.

BUTTERFLY VALVES

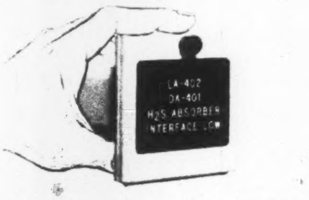
New 32,000 series of wafer-type Butterfly Valves features ruggedized actuator mounting, ease of adjustment, and accessibility. Design enables the connecting stem and link to be in line and at right angles to shaft arm at mid-stroke, for either 60° or 90° (or any intermediate point) operation. Actuation is either by power, handwheel, or lever. Available in sizes 2" to 24" in cast iron, cast alloys or flame-cut carbon.—*Mason-Neilan, Div. of Worthington Corp., Nahatan St., Norwood, Mass.*



For more information circle 188 on inquiry card.

STATIC SWITCHING ANNUNCIATOR

New individual Static Switching Annunciator, Model ST-DF, is a completely self-contained modular unit

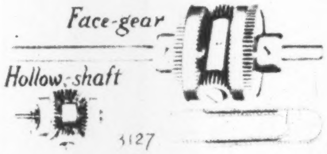


which eliminates relays and solenoids. It operates on 24-to-250-v ac or dc.—4-page brochure contains details.—*Scam Instrument Corp., 1811 West Irving Park Rd., Chicago 13, Ill.*

For more information circle **189** on inquiry card

DIFFERENTIALS

New ultraminiature hollow-shaft differentials are available as Class I or II in stainless steel. Three dif-

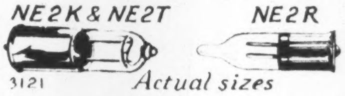


ferent models in $\frac{1}{16}$" and $\frac{1}{8}$" shaft sizes, 0.580" and 0.790" clearance diameters, 4 or 8 precision ball bearings, and 6′ 12′ and 15′ displacement arcs. ★ New face-gear differentials are available in 0.125" and 0.1875" shaft diameters to meet Precision Class I or II specifications in aluminum, bronze or stainless steel. Clearance diameter 0.875" and 10′ displacement arc.—*Dynamic Gear Co., Inc., 20 Merrick Rd., Amityville, N. Y.*

For more information circle **190** on inquiry card

SUBMINIATURE NEON LAMPS

Two innovations in neon lamps: (1) New NE2K and NE2T, said to "produce over twenty times as much light as their predecessors," retain "cold light" characteristics of neon; consume 0.25 watt at 2-ma design



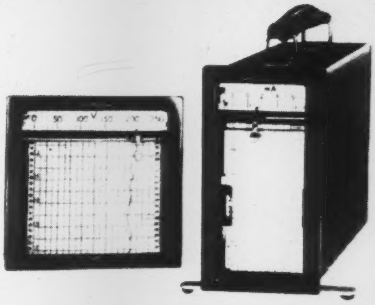
current. Service life from 5,000 hr to over 25,000 hr, depending on model. (2) New NE2R obviates need for a series resistor or external ballast, by incorporating current control as integral part of internal lamp structure. Average life expectancy over 25,000 hours. Operation is cold. Power consumption 0.1 watt at 1-ma design current.—*Circon Component Corp., Santa Barbara Municipal Airport, Goleta, Calif.*

For more information circle **191** on inquiry card

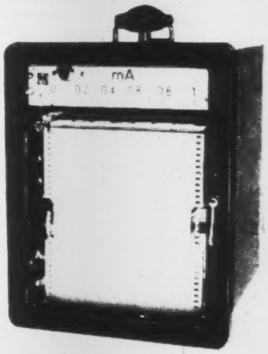
MINIATURE, STANDARD and DOUBLE SIZES!

MINIATURE RECORDERS

Square Model 85, in flush mount, weighs 16 lbs. and is 5⅝" square x 12¾" deep. Slim models 86 (portable) and 87 (flush) save half the width of standard recorders . . . measure 3¾" x 7⅛" x 8¾" and weigh only 9 lbs.



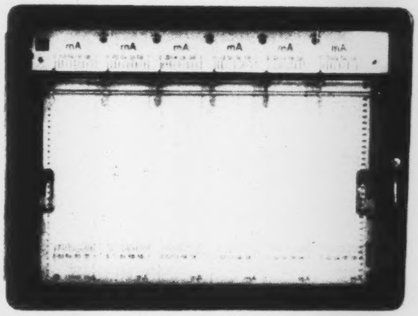
CURTISS-WRIGHT



STANDARD RECORDERS

Model 81 (portable) and 82 (flush) are also available for wall and projection mounting . . . take up to 3 channels. Weigh only 19 lbs. and measure 7½" x 9¹³⁄₁₆" x 7⅞".

PRECISION RECTILINEAR



DOUBLE SIZE RECORDERS

Models 83 (portable) and 84 (flush) take up to 6 channels. Wall and projection mounting available. Chart width is 9½". Measure 12¾" x 9¹³⁄₁₆" x 8¾" and weigh only 26 lbs.

STRIP CHART RECORDERS

Made under licensing agreements with one of Germany's leading instrument manufacturers . . . combine accuracy with ruggedness.

Important features: *Rectilinear Recording* with patented linkage that translates angular meter motion into proportional straight line • *Inkless and Ink Recording in One Unit* • *Three-Speed Transmission plus 60:1 Speed Change* from hours to minutes; provides six interchangeable speeds in all • *1% Accuracy* for moving coil movement • *Shock-proof movement . . . splash and dustproof steel cases.*

AC, DC, power and combination movements; wide choice of ranges and chart drives. Write for full information.

ELECTRONICS DIVISION
CURTISS-WRIGHT
CORPORATION • CARLSTADT, N. J.

For more information circle **94** on inquiry card.

New! **Low Temperature Freezer**

MINUS 120° F TO PLUS 300° F

- Serves many needs:—Laboratory Control, Industrial Research and Production.
- For Cold Treating, Stabilizing, Environmental Testing, Low temperature storage of metals, Rivet cooling, Shrink fitting, Gage seasoning, Steel hardening and Metallurgy.

invaluable in the field of
GUIDED MISSILES and ROCKETRY

Standard production model, (white) self-contained, including automatic controls.

34″ high—28″ deep—38″ wide—outside dimensions.

Complies with National B-9 Refrigeration Code.

New low price—immediate delivery (available without automatic controls, for Dry Ice Storage).

Alpha Electric Refrigeration Co.
1115 East Seven Mile Road • Detroit 3, Michigan

For more information circle **95** on inquiry card.

new
miniature
DC RELAY
with full size contacts
TYPE Z

AVAILABLE WITH PRINTED CIRCUIT TABS

Ideal for applications requiring compactness, sensitivity, easy mounting and economy. Features full-size contacts. Can be supplied with tabs for printed circuit use. Send for details.

COMAR
ELECTRIC COMPANY
3349 ADDISON ST., CHICAGO 18, ILL.

RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

For more information circle **96** on inquiry card.

new plants and mergers

GEOTECHNICAL CORP. has moved to a new 40,000-sq-ft plant in Garland, Tex.

KELLOGG SWITCHBOARD & SUPPLY CO. has organized a new systems engineering division.

TELECOMPUTING CORP. has acquired the **FRANK R. COOK CO.** which will become a division of the parent company.

GEORGE GREGORY AND ASSOCIATES, with offices in West Newton, Mass., have been named New England sales representatives for **CUBIC CORPORATION**, San Diego (Calif.) electronics manufacturing firm.

SYSTRON CORP. has completed a 15,000-sq-ft expansion of its quarters.

UNION CARBIDE OLEFINS CO. has licensed **GREENBRIER INSTRUMENTS** to manufacture a new process-stream analyzer.

CENTURY ELECTRONICS & INSTRUMENTS has appointed AHMCO as representative for the North Western States.

FLOW MEASUREMENTS CORP. is a new organization closely associated with **WEINSCHEL ENGR. & MFG. CORP.**, Kensington, Md.

Adjustable
conax®
PIPE CLAMP THERMOCOUPLE

for accurately reading outside pipe temperatures

advantages

- Used wherever immersion thermocouples are impractical or undesirable
- Used where extreme corrosion and erosion are problems
- Provides temperature readings on alloy, plastic or glass pipes that are not easily entered
- High pressure lines unbroken—a safety feature
- Installation and service without interrupting operations or flow
- Permits checking other temperature measuring devices
- Checks effectiveness of insulation
- Multiple units readily used for obtaining temperature gradients
- Installed in less than a minute

Thermocouples available in Copper-Constantan for low temperatures or Iron—Constantan and Chromel—Alumel up to 1000° F.

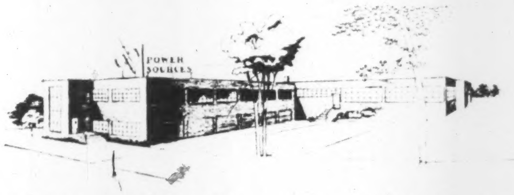
WRITE FOR CONAX DATA BOOK SHOWING COMPLETE LINE OF THERMOCOUPLE ASSEMBLIES AND PRESSURE SEALING GLANDS.

conax corporation
2316 Walden Ave., Buffalo 25, N. Y.

For more information circle **97** on inquiry card.

UNIVERSAL CONTROLS will expand research and manufacture after electing Carl P. Clare of its subsidiary to executive vice president of the parent company.

MINNEAPOLIS-HONEYWELL announces a 40% expansion of its plant capacity at Beltsville, Md.



POWER SOURCES, INC. is building an 18,000-sq-ft plant at Burlington, Mass., to be ready in March 1959.

B-I-F INDUSTRIES has opened a new regional sales office in Baton Rouge, La.

people in the news

CROSBY VALVE & GAGE CO. announces election of *Jere. J. Bresnahan* to vice president of sales.

BALDWIN-LIMA-HAMILTON has appointed *Carey A. Evans* as manager of engineering, Electronics & Instrumentation Div.

TECHNOLOGY INSTRUMENT CORP. of California announces appointment of *Ray Destabelle* to chief engineer, Transducer Div.

GAUGES NOW COMPLETELY CATALOGED WITH ENGINEERING DATA

FOR PROCESS & POWER INSTRUMENTATION

IN PLANT & O.E.M.

KUNKLE GAUGES

Complete, broad range line makes gauge application-specification easy with assured results backed by 50 years of gauge manufacturing experience.

Ranges from 15 p.s.i., or 30" of vacuum, to 20,000 p.s.i.

Bourdon tubes of bronze, drawn or bored s/s, and other alloys

YOUR COPY SHOWING NEW GAUGES AND SPEC. DATA NOW AVAILABLE WRITE:

By the makers of dependable Kunkle Valves

KUNKLE VALVE CO. • FT. WAYNE, IND.

For more information circle **98** on inquiry card.

A. D. JONES OPTICAL WORKS

2400 MASSACHUSETTS AVENUE
CAMBRIDGE 40 MASSACHUSETTS
TRowbridge 6-3368—3369

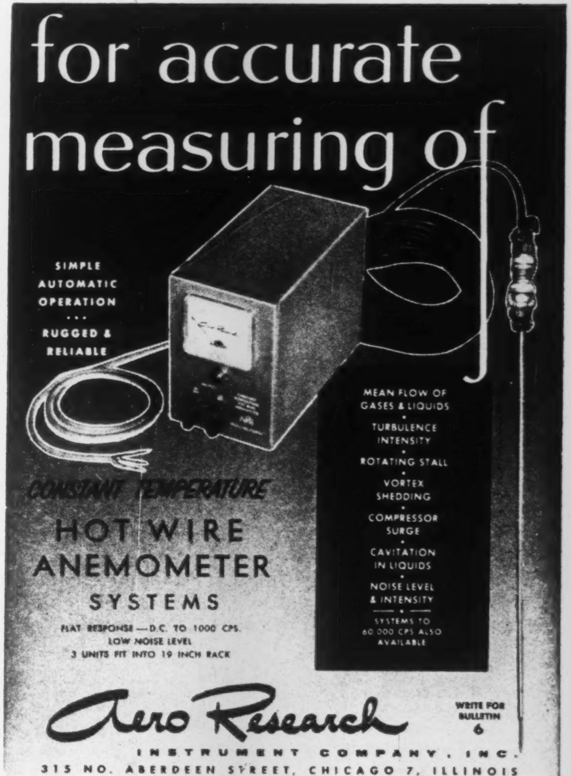
A LIST OF MATERIALS WE FABRICATE USED IN OPTICS AND ELECTRONICS

SAWING GRINDING POLISHING DRILLING

ALUM
ALUMINA
ALUMINUM
ANTHRACENE
ARSENIC TRISULPHIDE
BARIUM TITANATE
BISMUTH
BRASS
CARBORUNDUM
CERAMIC
COPPER
*CORNING 707
*CORNING 7052
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GERMANIUM
INDIUM ANTIMONITE
INDOX
MELAMINE FIBER GLASS
MICA, SYNTHETIC
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
**STEEL
STRONTIUM TITANATE
TITANIUM DIOXIDE
*VYCOR
*X-RAY LEAD GLASS
ALL TYPES KNOWN GLASS

*Carried in stock
**Purchased for orders

For more information circle **99** on inquiry card.


for accurate measuring of

SIMPLE AUTOMATIC OPERATION . . . RUGGED & RELIABLE

MEAN FLOW OF GASES & LIQUIDS • TURBULENCE INTENSITY • ROTATING STALL • VORTEX SHEDDING • COMPRESSOR SURGE • CAVITATION IN LIQUIDS • NOISE LEVEL & INTENSITY

SYSTEMS TO 60,000 CPS ALSO AVAILABLE

CONSTANT TEMPERATURE HOT WIRE ANEMOMETER SYSTEMS

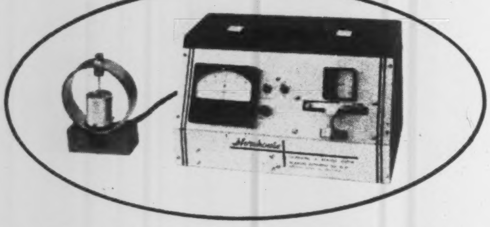
FLAT RESPONSE — D.C. TO 1000 CPS.
LOW NOISE LEVEL
3 UNITS FIT INTO 19 INCH RACK

Aero Research INSTRUMENT COMPANY, INC.
315 NO. ABERDEEN STREET, CHICAGO 7, ILLINOIS
SALES REPRESENTATIVES THROUGHOUT THE UNITED STATES AND CANADA

WRITE FOR BULLETIN 6

For more information circle **100** on inquiry card.

NEW
MOREHOUSE CALIBRATING AND WEIGHING SYSTEM
- COMPLETELY TRANSISTORIZED
- BATTERY-POWERED
- EXTREMELY ACCURATE



The new Morehouse Calibrating and Weighing System facilitates the accurate calibration of load cells, thrust stands, torque dynamometers, testing machines and other force measurement equipment. It is also applicable as a prime weighing system where extremely high accuracy is essential.

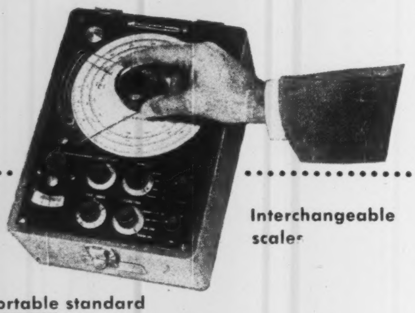
The System has been transistorized for ruggedness and reliability in addition to making battery operation possible. It is readily portable and easy to operate. For details, write for Bulletin 169.

Morehouse Machine Company
1742 Sixth Avenue, York, Pa.

For more information circle 101 on inquiry card.

Calibrate Pyrometers
. . . Measure Temperatures

Read temperatures or millivolts directly



Interchangeable scales

A portable standard

The Pyrotest checks recorders, controllers and thermocouples . . . measures temperatures. It is a precision signal source, simulating thermocouple temperatures, for checking other potentiometers. Built-in "run up" permits checking of millivoltmeters.

19 different stock scales will fit one Pyrotest! Scales interchange in seconds. F. or C. calibrations for all types of thermocouples supplied. Scales directly read temperatures or millivolts.

Features include cold junction compensation, high accuracy, built-in standard cell. Request Bulletin 9B for complete specifications.

TECHNIQUE ASSOCIATES INC.
P. O. BOX 91 • INDIANAPOLIS 6, INDIANA
For more information circle 102 on inquiry card.

PEOPLE IN THE NEWS—*Continued*

H. L. Spaunburg

W. C. Stauble

W. J. Bloudek

VEEDER-ROOT INC. announces election of *Harvey L. Spaunburg* to chairman of the board, and *Wilbur C. Stauble* to president.

SKINNER CHUCK CO. announces appointment of *William J. Bloudek* as sales manager.

TRINITY EQUIPMENT announces appointment of *Edward M. Feeley* as vice president of sales, and *Thomas A. Boyle* as vice president of manufacturing.

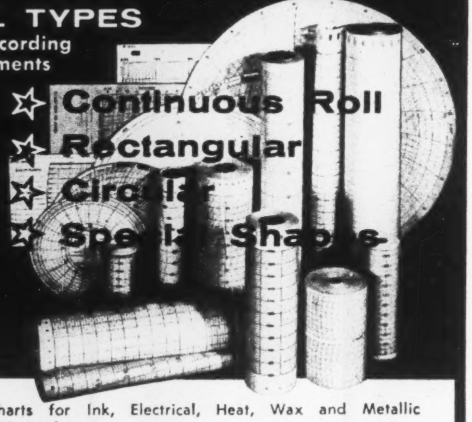
MINNEAPOLIS-HONEYWELL, Boston Div., reports that *George J. Schwartz,* its president and general manager, has been elected president of the American Ordnance Association, Yankee Post.

ROCHESTER MFG. CO. has elected *Clark L. Hastings* president.

HICKOK ELECTRICAL INSTRUMENT CO. announces appointment of *H. D. Johnson* as director of marketing.

EAGLE SIGNAL has appointed *Vincent C. Blecker* to sales manager of the Industrial Div.

GUBELMAN CHARTS
ALL TYPES
for Recording Instruments



☆ Continuous Roll
☆ Rectangular
☆ Circular
☆ Special Shapes

Charts for Ink, Electrical, Heat, Wax and Metallic Stylus-Recording.

Special time numbering, perforations, and graphic design cycles available to meet unusual requirements.

All Charts are produced under automatically controlled atmospheric humidity conditions.

Our complete chart manufacturing facilities and wide experience have served and progressed with the instrument industry since 1908.

GUBELMAN CHARTS INCORPORATED
(FORMERLY NAMED GUBELMAN PUBLISHING CO.)
100-106 EAST KINNEY STREET, NEWARK 5, N. J.

A. E. Beckers

R. Barlow

C. C. Snider

J. A. Dayton

A. W Richart

J. T. Muller

ALLEN B. DuMONT LABS. announces appointment of *Albert E. Beckers* as director of engineering.

BARTON INSTRUMENT CORP. announces that *Richard Barlow* has joined the company as manager of the sales and application engineering department.

CONSOLIDATED ELECTRODYNAMICS announces appointment of *Charles C. Snider* as director of sales.

AMERICAN METER CO. has elected *James A. Dayton* vice president of manufacturing.

LESLIE CO. announces *Arthur W. Richart* has been appointed chief engineer, Product Engineering, and *J. Thomas Muller* manager, R & D.

WHAT MAKES THE DIFFERENCE?

In producing ultra critical and non critical elements customized to your specifications Plummer and Kershaw's AUTOMATIZED production brings to you the finest precisioned optics in the field

PLUMMER AND KERSHAW has an established reputation for outstanding reliability, superior quality and accuracy at lowest cost

Feel free to call on us to help you solve your particular problem

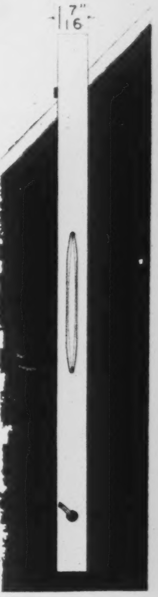
PLUMMER AND KERSHAW your most experienced source

p&h

PLUMMER and KERSHAW
2759 Frankford Ave., Philadelphia 34, Pa.

Request Bulletin 737 on your Letterhead

For more information circle **104** on inquiry card.



where you need it . . .
when you need it!

PORTA-TRACE

EXTRA-THIN LIGHT BOX
- *only 1-7/16" deep; with a straight edge, makes a self-contained drafting unit for field or desk.*

Really portable, this tracing unit is ready for use in seconds, stores like a book when the job is done! Designed for maximum versatility, PORTA-TRACE fits under parallel rule on the drafting board; flush top permits use with drawings larger than the unit itself.

- can be used to trace on bristol board, Multilith mats, or to strip-in and opaque negatives
- rust-proof, stainless steel frame; shatter-proof, diffuser top, built-in start-stop switch
- rubber feet hold it at any angle
- available in 5 sizes up to 36¼" x 48¼", starting at 32.50

Write today for complete information and prices!

PORTA-TRACE INC.
50 Wall St. **Binghamton, N. Y.**

For more information circle **105** on inquiry card.

NEW AGASTAT®

HAS LONGER OPERATING LIFE

The Agastat time/delay/relay has been completely re-designed, inside and out, to make every moving part last longer and operate more reliably. Here are some other important advantages:

- Dial adjustment for ease and accuracy
- Five timing ranges, covering an overall range of from 0.08 seconds to 15 minutes
- Timed intervals remain the same through repeated readjustments
- Integral wiring diagram and calibration plate
- Measures only 4-9/16 x 2-9/16 x 2-5/8"
- All contacts are flexible contacts
- Contacts are larger for fast heat dissipation

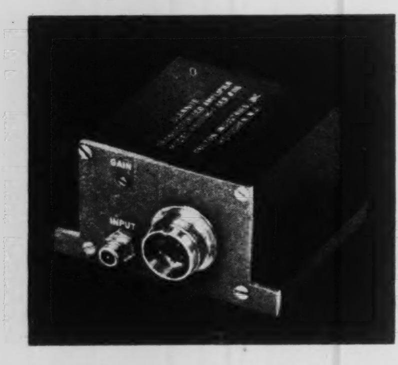
Write for details and application engineering assistance to Dept. **A32-1226.**

AGA
DIVISION

Elastic Stop Nut Corporation of America
1027 Newark Avenue, Elizabeth, New Jersey
Pioneers in Pneumatic Timing

For more information circle **106** on inquiry card.

28 volts powers this transistorized vibration amplifier



Consuming only a fraction of the power required by tube type units, taking ⅓ the space, and operating directly from a 28 volt battery, this GLENNITE transistorized amplifier fills all requirements for airborne application.

Unique design and rugged construction assure extremely low microphonics, provide high input impedance for direct use with piezoelectric accelerometers.

A companion light weight, 3-channel battery pack is available. This unit contains a rechargeable, sealed nickel cadmium battery capable of powering 3 transistorized amplifiers for 16 hours.

Like more data on these units? Contact your local Gulton representative, or write us direct.

SPECIFICATIONS

Gain: Continuously variable from 10 to 100
Input impedance: 30 megohms minimum
Power input: 28 v dc at less than 3 ma
Frequency range: 10 cps to 20 KC
Temperature range: up to 200° F

Call in Gulton

Whether you need a single instrument or a complete system, Gulton is capable of meeting all your needs in shock and vibration measurement from transducer to readout equipment. Call in a Gulton Instrumentation Engineer on your next assignment — or on your present one if you have a problem.

GULTON INSTRUMENTATION DIVISION

Gi
Gulton Industries, Inc.
Metuchen, New Jersey

For more information circle **107** on inquiry card.

new literature

AUTOMATION-CONTROL

DIESEL ENGINE CONTROLS are described in new 24-page Bulletin B45-1. —Minneapolis-Honeywell Regulator Cp., Industrial Div., Wayne and Windrim Ave., Phila 44, Pa.

For more information circle **192** on inquiry card.

POWRLOG RECEIVER specifications and description are given in new 8-page Specification Sheet OE-10003.—Hagan Chemicals & Controls, Inc., P. O. Box 1346, Pittsburgh 30, Pa.

For more information circle **193** on inquiry card.

RECORDERS, CONTROLLERS, INDICATORS. 12-page Bulletin GEA-6792, provides descriptive information on new Type HF single-point, and HG multi-point strip-chart recorders and recording controllers; Type HE round-chart recorder, recording controller, and circular scale indicator; and Type HF precision indicator; and on available control forms.—General Electric Co., Schenectady 5, N. Y.

For more information circle **194** on inquiry card.

LIQUID LEVEL, PRESSURE, temperature control pilots are subject of new 8-page Bulletin 5303.—Leslie Co., Lyndhurst, N. J.

For more information circle **195** on inquiry card.

PHOTOGRAPHIC AUTOMATION. 32 page booklet NO: "Register Photographically!" on photographic automation with the motor-driven Robot 35 mm camera describes applications of the electro-automatic registration system.—Karl Heitz, Inc., 480 Lexington Ave., New York 17, N. Y.

For more information circle **196** on inquiry card.

DRUM-TYPE CONTROLLERS are described in new 8-page bulletin.—Seely Inst. Co. Inc., P. O. Box 387, Niagara Falls, N. Y.

For more information circle **197** on inquiry card.

SORTING MACHINE. 2-page Brochure B-35 describes Precision Sorter which gages and sorts 300,000 small parts per hour to ±0.0003".—U. S. Engineering Co., Dept. IA, 40-24 22nd St., Long Island City 1, N. Y.

For more information circle **198** on inquiry card.

MOTORS

FHP MOTORS. 22-page Motor Catalog M 159 details full specs and data on about a dozen small motors, ranging from 1/1000 to 1/3 hp and including universal, d-c, a-c and permanent-magnet types, induction, gear motors, governor, and brake motors.—Carter Motor Co., 2707A W. George St., Chicago 18, Ill.

For more information circle **199** on inquiry card.

SYNCHRONOUS MOTORS. 32-page Catalog EI-4 contains detailed data on over 200 representative Elinco synchronous motor designs, includes tech-

For your library . . .

Heat Inertia Problems of Automatic Control of Temperature

by Victor Broida, based on the concept of "fictitious mass" of heating process unit under automatic control. 1950. paper, 5¼" x 8¼", 61 pages. $1.00

The Automatic Factory

by June, Bardis, Lurio, Polaner, Sagedahl, Sklenar and Yenken. Here is THE book for all who want FACTS rather than wild opinions . . . a fresh viewpoint on what "manless factories" CAN be—a book free from the generalities, platitudes, exaggerations and misconceptions repeated by many writers on this subject. 1955. cloth, 88 pages, illustrated. $1.50

Electronic Circuitry for Instruments and Equipment

by M. H. Aronson. "Comprehensive source book on instrument circuitry," this complete home-study text includes 458 multiple-choice questions (and answers), 215 illustrations, 10 tables, comprehensive index. Paperbound, 324 pages, 1957 (revised edition). $2.00

Applications of Industrial pH Controls

by A. L. Chaplin. "pH is a concentration variable which responds to and is a measure of the effects of a chemical reaction . . . and follows a non-linear control relationship" presenting unique problems in pH control application. Clothbound, 144 pages, 1950. $2.00

Nuclear Reactors for Industry and Universities

Edited by Ernest H. Wakefield. Covers types, availability, operation, protection, control, experiments, legal aspects, and detailed cost study. 1954. cloth, 92 pages. $2.00

The Electronic Control Handbook

by R. R. Batcher and William Moulic. Presents electrical and electronic principles applicable to measurement and automatic control. 1946. paper, 244 pages. $2.00

Mechanical Measurements by Electrical Methods

by Howard C. Roberts (Second Edition) . . . Thorough treatment on a subject much in need of the correlation given it . . . Serialized in INSTRUMENTS under the title "Electric Gaging Methods." 1951. cloth, 368 pages, illustrated. $2.00

Instruments Publishing Co.
845 Ridge Avenue
Pittsburgh 12, Pa.

nical information on the theory and application of all types of synchronous motors.—Electric Indicator Co., Inc., Camp Ave., Stamford, Conn.

For more information circle 200 on inquiry card.

MOTORS. for all types of office machines, are discussed in 4-page Motorgram, Vol. 38 No. 5.—Bodine Electric Co., 2500 West Bradley Place, Chicago 18, Ill.

For more information circle 201 on inquiry card.

SYNCRAMENTAL STEPPING MOTORS are described with specifications in new Bulletin 958SM2.—G. H. Leland, Inc., 123 Webster St., Dayton 2, Ohio

For more information circle 202 on inquiry card.

VALVES

CONTROL VALVES. 12-page Bulletin LB-3 gives details on construction and operating characteristics of the Series LB control valve.—Conoflow Corp., Dept. D-6, 2100 Arch St., Phila. 3, Pa.

For more information circle 203 on inquiry card.

HIGH-PRESSURE REDUCING VALVE. 2-page catalog sheet describes the new Type E, Fig. 198 high-pressure reducing valve.—Atlas Valve Co., 280 South St., Newark 5, N. J.

For more information circle 204 on inquiry card.

VALVES AND REGULATORS. 6-page Bulletin 601-B presents in short form pictorial and descriptive information on directional air control valves, regulators and filters, power cylinders, and hydraulic pressures.—Hannifin Co., 541 S. Wolf Rd., Des Plaines, Ill.

For more information circle 205 on inquiry card.

FLOW CONTROL SERVO VALVES are described in new 6-page brochure.—Moog Valve Co., Inc., Proner Airport, East Aurora, N. Y.

For more information circle 206 on inquiry card.

TEMPERATURE

TEMPERATURE SENSORS. 2-page bulletin describes diaphragm temperature sensors for use in home and commercial appliances.—Robertshaw-Fulton Controls Co., Bridgeport Thermostat Div., Milford, Conn.

For more information circle 207 on inquiry card.

DIGITAL INDICATOR 4-page brochure presents information on cockpit indicator of exhaust gas temperature (EGT) or turbine inlet temperature (TIT) of jet engines.—B & H Instrument Co., Inc., 3479 West Vickery Blvd., Fort Worth 7, Texas.

For more information circle 208 on inquiry card.

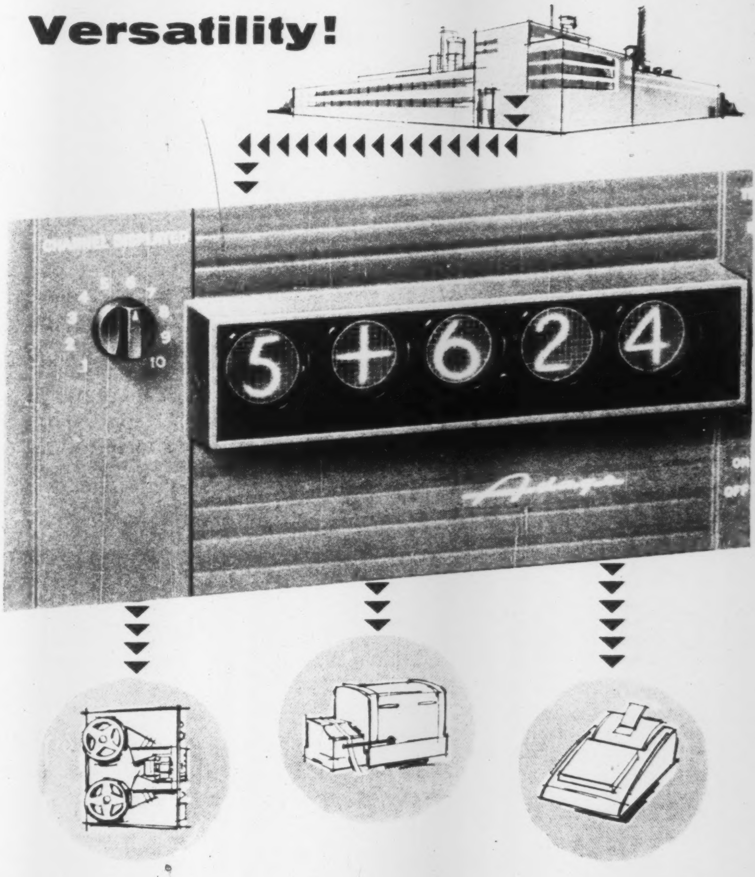
TEMPERATURE CONTROL. 4-page short-form Catalog covers complete line of thermistor-based temperature measurement and control instruments.—Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio

For more information circle 209 on inquiry card.

VACUUM THERMOCOUPLE GAGE and Control are described in new technical data sheet.—NRC Equipment Corp., 160 Charlemont St., Newton 61, Mass.

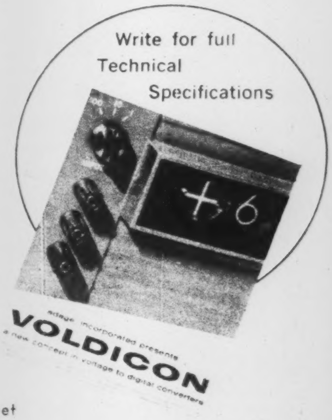
For more information circle 210 on inquiry card.

New Adage Converters
Offer Unlimited
Versatility!



Unlimited Versatility? — a large statement. But the facts back it up! Voldicon will translate inputs from any source into any storage device.
Name your input: thermocouple, strain gage, telemetry data, analog computer (there are too many possibilities to list here) . . . Name your output: magnetic tape, tape punch, printer, digital computer . . . Voldicon will handle any combination.
Whatever your needs there is a Voldicon model designed to answer your problems . . . well within your budget.

NEW VOLDICON FEATURES:
- New Transistor Design
- New Speed — up to 10,000 separate conversions per second
- New Accuracy and Reliability


+6
adage incorporated presents
VOLDICON
a new concept in voltage to digital converters

Write for full
Technical
Specifications

Adage
INCORPORATED
Department IA-12, 292 Main Street
Cambridge 42, Mass.

For more information circle 109 on inquiry card.

DOMOTOR DOES MORE IN THE ACCURATE, AUTOMATIC *CONTROL* OF HARD-TO-HANDLE FLUIDS

MODEL 1560
DOMOTOR
Control Valve

Is your problem the precise control of erosive and corrosive fluids at high or low temperatures?

If so, investigate the ANNIN DOMOTOR control valve, wherein internally controlled differential pressures, acting across a sealed-in piston, provide the motive power for operation. The DOMOTOR combines powerful valve action with exceptional stability, greater plug travel and guaranteed positioning accuracy of 1/1000 of valve travel.

Standard models withstand pressures to 5,000 psi with special applications to 50,000 psi. Effective temperatures from −425°F to 1600°F.

Other models by Annin—
Solenoid-operated, Model 1520
Handwheel Valve, Figure 15

ANNIN

Write today for Catalog 1500B

THE ANNIN COMPANY
Div. of The Annin Corporation
1040 S. Vail Avenue
Montebello, California

Control VALVES

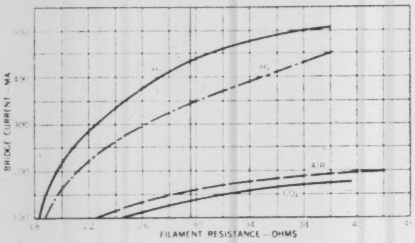
For more infromation circle **110** on inquiry card.

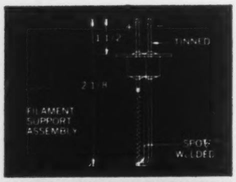
GAS ANALYSIS BY THERMAL CONDUCTIVITY SINCE 1935

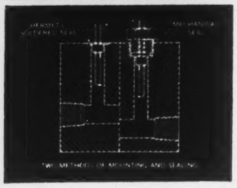
Now! Available from Stock!

GOW-MAC
HIGH POSITIVE COEFFICIENT
RESISTANCE FILAMENTS

For Repair, Experiment and Instruction with
- Detectors for Gas Chromatography
- Gas Analysis by Thermal Conductivity
- Temperature Resistance Measurement — 60 ohms maximum working resistance without destruction







[illegible]	FORM	COLD	[illegible]	[illegible]	[illegible]
TUNGSTEN	HELIX	20	30	150	$10.00
TUNGSTEN (GOLD PLATED)	HELIX	18	27	150	20.00
KOVAR (ALLOY OF NICKEL, COBALT, IRON)	STRAIGHT	4	7	200	10.00

TUBE NUTS AVAILABLE. CAT. No. 9611 (Brass) Price Per Pair .50
*Minimum order $50.00

Other Gow-Mac Products
- Portable and Panel Instruments
- Power Supplies (20 V., 500 ma. D.C.)
- Thermal Conductivity Cells (Hot Wire and Thermistor)

Order for immediate shipment or send for Bulletin FIL. Address Department. IA.

GOW-MAC INSTRUMENT CO.
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For more information circle **111** on inquiry card.

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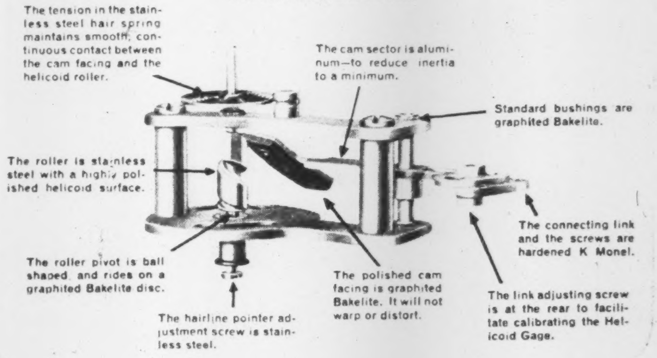
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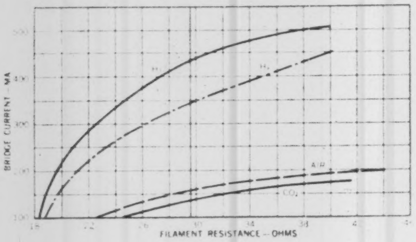

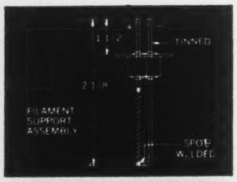

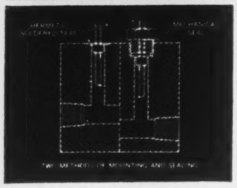

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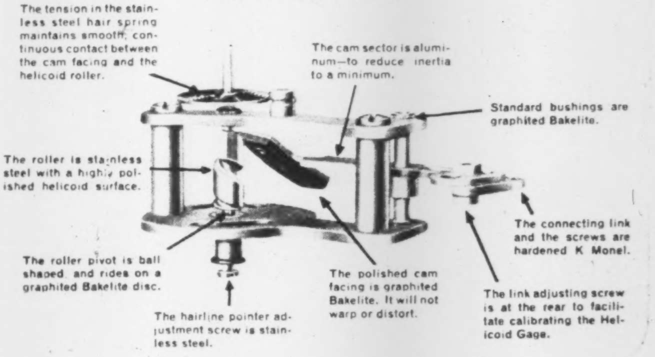

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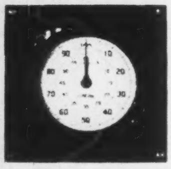

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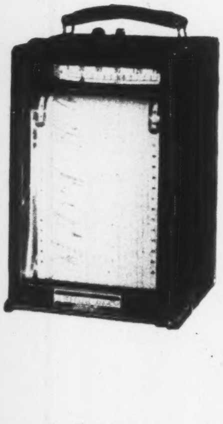

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CONTINUOUS pH CONTROL 2-page Application Data Sheet pH-4209 describes use of industrial pH equipment in the production of enamel printing paper.—Beckman/Scientific and Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.

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DATA HANDLING

PLEXICODER is described with specs in 8-page Bulletin 1599A.—Consolidated Electrodynamics, Transducer Div., 300 North Sierra Madre Villa, Pasadena, Calif.

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DECADE INDUCTORS are described with specs in 2-page Bulletin LP121.1.—Computer Engineering Associates Inc., 350 North Halstead, Pasadena, Calif.

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SHAFT POSITION ENCODER. 4-page Bulletin 8600 contains dimensions, specifications, and description of Precision Shaft Encoder and its components.—W. & L. E. Gurley, 514 Fulton St., Troy, N. Y.

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PROGRAMMING. 32-page booklet U-1555 "Programming—a New Profession for You" outlines with humorous illustrations the role of the programmer in industry. Includes bibliography of non-technical books on computers, and comprehensive list of colleges and universities offering courses in computing machinery and data-processing.—Remington Rand Div. of Sperry Rand Corp., 315 Fourth Ave., New York 10, N. Y.

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DATA PROCESSING. 12-page brochure "Burroughs Electrographic Recording Equipment" reviews high-speed electrographic printing and recording equipment for various branches of the military.—Burroughs Corp., Defense Sales Div., 66 [illegible] Second Ave., Detroit 32, Mich.

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COMPUTER LANGUAGE TRANSLATOR. 38-page brochure provides application information for the Model ZA-100 Computer Language Translator for translation between different types of electronic computers and related data-processing equipment.—Electronic Engineering Co. of Calif., 1601 E. Chestnut, Santa Ana, Calif.

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TRANSISTORIZED MEMORY. Engineering data sheet includes physical characteristics, control signals, speeds, and principles of operation of Transistorized Sequential Load-Unload 144 Character Memory System.—General Ceramics Corp., Keasbey, N. J.

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LOGIC UNIT BOARD. 8-page booklet describes the new Logic Unit Board, a highly versatile array of basic computer elements which can be connected easily to serve whole logic and control functions of complex digital computers.—General Mills, Inc., Mechanical Div., 1620 Central Ave., Minneapolis 13, Minn.

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A/D CONVERTER. 4-page Brochure DI.03 provides design information on a new device for shaft analog-to-digital conversion.—Telecomputing Corp., Data Instruments Div., 12838 Saticoy St., North Hollywood, Calif.

For more information circle **242** on inquiry card.

RECORDERS

MULTIPLE-POINT RECORDER/Controller Assembly is described in new 2-page data sheet ND46-33(6).—Leeds & Northrup Co., 4907 Stenton Ave., Phila. 44, Pa.

For more information circle **243** on inquiry card.

GRAPHIC INSTRUMENTS to cut costs are discussed in Bulletin 958.—The Esterline-Angus Co., Inc., P. O. Box 596, Indianapolis 6, Ind.

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IMAGE CONVERTER CAMERA, ultra-high speed, is described in new 2-page brochure.—Librascope Inc., Precision Technology Dept., 66 South P St., Livermore, Calif.

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TESTING

TESTERS. 12-page Catalog 59 contains illustrations and descriptions of 60 different testers for adhesives, cement, insulation, metals, paper, plastic, rubber, textiles, and fats-wax.—Custom Scientific Instruments, Inc., 541 Devon St., Kearny, N. J.

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WALK-IN CHAMBER. 6-page brochure on walk-in environmental chambers for temperature, altitude, and humidity, describes complete missile-test facilities.—Conrad, Inc., Conrad Square, Holland, Mich.

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TESTING FACILITIES 25-page brochure presents information on environmental testing laboratory facilities for evaluation and testing of all types of commercial and military equipment.—Belock Instrument Corp., 111-01 14th Ave., College Point, N. Y.

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PRECISION GAGES AND TOOLS. 12-page catalog presents photographs and digest descriptions of optical, electronic, and mechanical tools, gages, and inspection devices.—Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill.

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SYNCHRO DATA CHARTS are available on request.—Theta Instrument Corp., 48 Pine St., East Paterson, N. J.

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COMMUNICATIONS

ITV with automatic light control compensating for light variations of up to 1000:1 is described in 2-page bulletin.—Kin Tel, Div. of Cohu Electronics, 5725 Kearny Villa Rd., San Diego 12, Calif.

For more information circle **251** on inquiry card.

WAVEGUIDE WINDOWS. 6-page folder tabulates, illustrates and explains uses of pressurizing windows.—Bomac Laboratories, Inc., 1 Salem Rd., Beverly, Mass.

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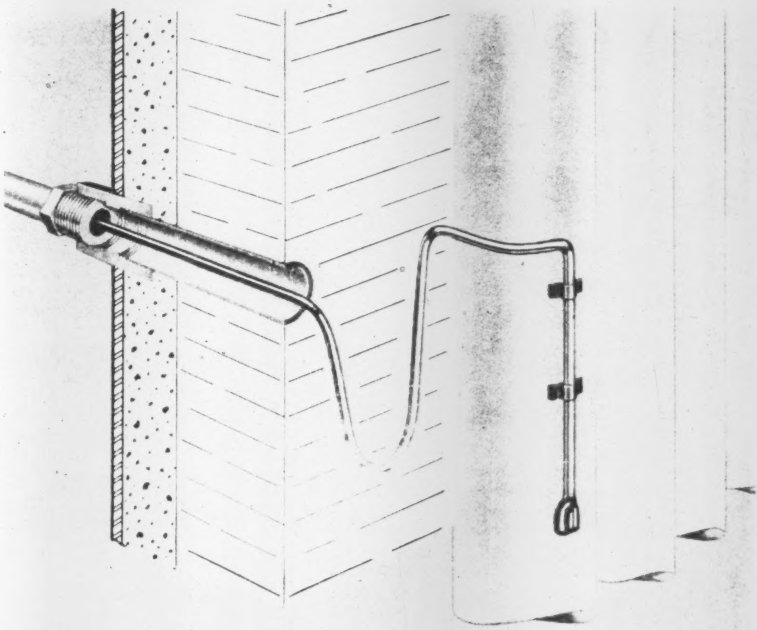

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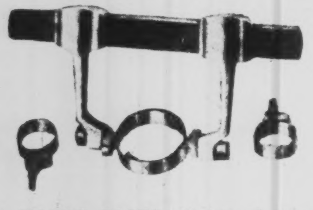

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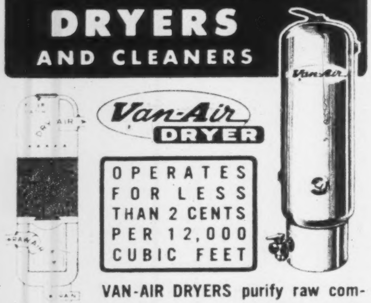
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LEVEL SET ATTENUATORS are described in new 2-page bulletin.—Polytechnic Research & Development Co. Inc., 202 Tillary St., Brooklyn 1, N. Y.

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ELECTRICAL, ELECTRONIC INSTRUMENTS

SERVO AMPLIFIERS, miniaturized, with power ratings to 16 watts are described with specs in new 4-page Brochure S-893.—Magnetic Amplifiers Inc., 632 Tinton Ave., New York 55, N. Y.

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MINIATURE TRANSFORMERS 2-page circular describes and illustrates new line of mu-metal-shielded epoxy-impregnated miniature transformers (Transistor Transformerettes) for transistor application.—Amplifier Corp. of America, Transformer Div., 398 Broadway, New York 13, N. Y.

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TONG TEST AMMETERS, 8-page catalog on Tong Test a-c/d-c ammeters gives detailed information on the selection and use of 8 types.—Columbia Electric Mfg. Co., 4519 Hamilton Ave., Cleveland 14, Ohio.

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ELECTRONIC INSTRUMENTS, 4-page short form catalog describes Accelerator Current Integrator, Universal Photomultiplier Photometer, Milli-Microsecond Time-to-Pulse-Height Converter, Multi-Channel Pulse Height Analyzer, Non-Overloading Linear Amplifier, and Milli-Microsecond Time Measuring System.—Eldorado Electronics, 2821 Tenth St., Berkeley, Calif.

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RMS VOLTMETER is described in 4-page Bulletin 42 and 2-page Bulletin 44.—Flow Corp., 85 Mystic St., Arlington, Mass.

For more information circle 258 on inquiry card.

MINIATURIZED VTVM's are described in new 4-page short form Catalog 10-A.—Metronix Inc., Chesterland, Ohio

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RESISTORS, POTENTIOMETERS

PORTABLE POTENTIOMETERS, 8-page Bulletin 110 describes maker's line for plant and laboratory, and includes the new E-3067 laboratory standard.—Gray Instrument Co., 200 East Church Lane, Phila. 44, Pa.

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POWER RESISTORS, 2-page Bulletin BR-9-58 illustrates and tabulates with electrical and mechanical specifications flat and stack-mounting power resistors.—Hardwick, Hindle, Inc., 40 Hermon St., Newark 5, N. J.

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PRECISION POTS are described in new 6-page brochure.—Technology Instrument Corp., 7229 Atoll Ave., North Hollywood, Calif.

For more information circle 262 on inquiry card.

POWER SUPPLIES

POWER SUPPLIES, transistorized, are featured in 8-page specification bulletin.—Lambda Electronics Corp., 11-11 131 St., College Point 56, N. Y.

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DUAL POWER SUPPLY, super-regulated, tracking type, is described with specs in new 12-page Bulletin SR-400.—George A. Philbrick Researches, Inc., 285 Columbus Ave., Boston 16, Mass.

For more information circle **264** on inquiry card.

DRY BATTERIES. 100-page manual outlines use and selection of dry batteries. Free to engineers engaged in the design of battery-powered equipment; others $1.00.—Burgess Battery Co., Dept. PR-1, Freeport, Ill.

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ELECTRONIC AMPLIFIER and Power Supply are described in technical data bulletin EE-1005.—Seneca Falls Machine Co., Electronics Div., Seneca Falls, N. Y.

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ELECTRICAL, ELECTRONIC COMPONENTS

ELECTRONIC PARTS AND EQUIPMENT, 452-page catalog lists over 32,000 items, including electronic tubes, transistors, semi-conductors and diodes, test instruments, transformers, printed circuit components, relays, rectifiers, photo-electric components, 2-way radio-telephones, sound counters, program clocks, timers, power supplies, etc., etc.—Allied Radio Corp., 100 N. Western Ave., Chicago 80, Ill.

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PRECISION ASSEMBLY KITS are described in new 16-page brochure.—Servo Corporation of America, 20-20 Jericho Tpke., New Hyde Park, L. I., N. Y.

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PREAMPLIFIERS. 8-page Bulletin P-15 describes preamplifier, Type PA4401-001 3VA including physical and electrical characteristic curves.—Control, Div. of Magnetics, Inc., Box 391, Butler, Penna.

For more information circle **269** on inquiry card.

PHOTO-VOLTAIC CELLS. 4-page Technical Information Bulletin 33-58 describes newly-developed line of silicon photo-voltaic readout cells.—Hoffman Electronics Corp., 930 Pitner Ave., Evanston, Ill.

For more information circle **270** on inquiry card.

ELECTRON TUBE RETAINERS 12-page Catalog 2-TT provides descriptive information on top-holding tube and component retainers.—Birtcher Corp., Industrial Div., 4371 Valley Blvd., Los Angeles 32, Calif.

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ADJUSTABLE DELAY LINES. 2-page Catalog Sheet DT-140 provides details on Type 140 for long time delays.—Deltime, Inc., 608 Fayette Ave., Mamaroneck, N. Y.

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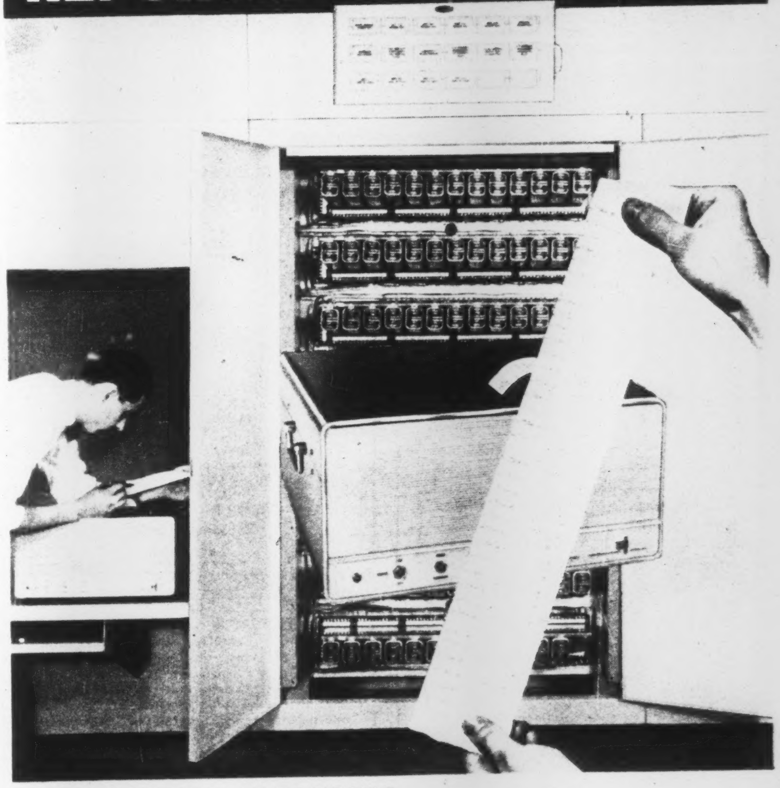

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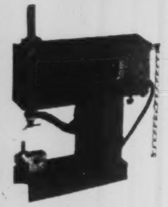

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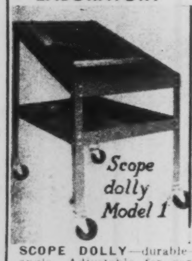

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NEW LITERATURE—Cont.

DELAY LINES. Bulletin 213 describes the characteristics of distributed constant delay lines and the models available from stock.—JFD Electronics Corp., 6101 Sixteenth Ave., Brooklyn 4, N. Y.

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REPLACEMENT VIBRATORS. One-page catalog lists complete specifications of 8 standard vibrator models for replacements.—James Vibrapowr Co., 4050 North Rockwell St., Chicago 18, Ill.

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CHOPPER INVERTERS for low level d-c measurements are described in new 9-page brochure.—Microdyne, 300 W. Washington, Chicago 6, Ill.

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RECTIFIER REPLACEMENT GUIDE contains 46 pages of information on replacement of damaged rectifiers.—Conant Labs., 6500 O St., Lincoln, Neb.

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SOLDER TERMINALS, with specification drawings, are featured in new 14-page Catalog 158.—Alpine Electronic Components, Inc., Waterbury, Conn.

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SELENIUM RECTIFIERS, cartridge type, are described in new 8-page catalog.—Syntron Co., 669 Lexington Ave., Homer City, Penna.

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CONNECTORS

RF COAXIAL connectors are described in new 18-page catalog ALRF-1.—Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

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SIDE-MOUNTED CONNECTORS. 2-page bulletin gives specifications, outline dimensions, and general information on Series "G" miniature connectors, manufactured by Continental Connector Corp.—DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

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FACILITIES, FABRICATION, SHOP EQUIPMENT

PRECISION WELDING EQUIPMENT. 4-page short-form describes equipment specially designed to join light-gage materials ranging from 0.0003" to 0.080".—Vacuum Tube Products Co., 2020 Short St., Oceanside, Calif.

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MOLDING FACILITIES. 4-page folder illustrates and describes design and manufacturing facilities for precision custom molding from all thermosetting materials.—Delta Plastics Co., Creek Rd., Bellmawr, N. J.

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GLASS BLOWING, for scientific instruments, research and development is described in 4-page bulletin.—Glass Instruments Inc., 2285 East Foothill Blvd., Pasadena, Calif.

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MINIATURE DRILLS, etc. are described in new 8-page bulletin.—Super Tool Co., 21650 Hoover Rd., Detroit 13, Mich.

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FILTER DESIGN Techniques are subject of 4-page engineering Bulletin 61. —Rixon Electronics Inc., 2414 Reedie Dr., Silver Spring, Md.

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CORE WINDING MACHINES. 20-page Catalog 7 pictures and describes Automatic Toroidal Core Winding Machines manufactured in Germany.—Rex Rheostat Co., 3 Foxhurst Rd., Baldwin, L. I., N. Y.

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MISCELLANEOUS

GRADUATING AND CALIBRATING. 12-page pamphlet describes operations for applying calibrations and graduations to scale beams, bars, rules, dials, etc. by use of various standard marking machines.—Acromark Co., 378 Morrell St., Elizabeth 4, N. J.

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ALUMINUM NAMEPLATES. 4-page Bulletin 177 describes application of self-bonding Quik-Plates to different types of surfaces. Free testing samples available.—W. H. Brady Co., 727 West Glendale Ave., Milwaukee 9, Wis.

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COATINGS. 36-page brochure provides information on clear and colored industrial coatings for use on metal, plastics, glass and wood.—Bee Chemical Co., 12933 South Stony Island Ave., Chicago 33, Ill.

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PVC MOLECULAR MODELS. 2-page bulletin illustrates Godfrey Models for plastic representation of molecular structures, strained ring systems, reaction mechanisms, hydrogen bonding, etc.—Will Corp., Box 1050, Rochester 3, N. Y.

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PACKAGE ENGINEERING for product protection is discussed in new 8-page brochure.—Armour Cushioning Products Div., Armour & Co. North Benton Rd., Alliance, Ohio.

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INSULATION ADHESIVES and Sealers are described in new 4-page catalog.—Minnesota Mining and Mfg. Co., Adhesives, Coatings, and Sealers Div., 423 Piquette Ave., Detroit 2, Mich.

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TUBING AND CABLE SUPPORTS are described in new 78-page Catalog 858. —P-W Industries, Inc., Duncan and Melrose Sts., Phila 24, Pa.

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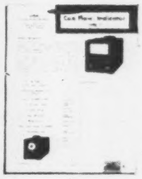

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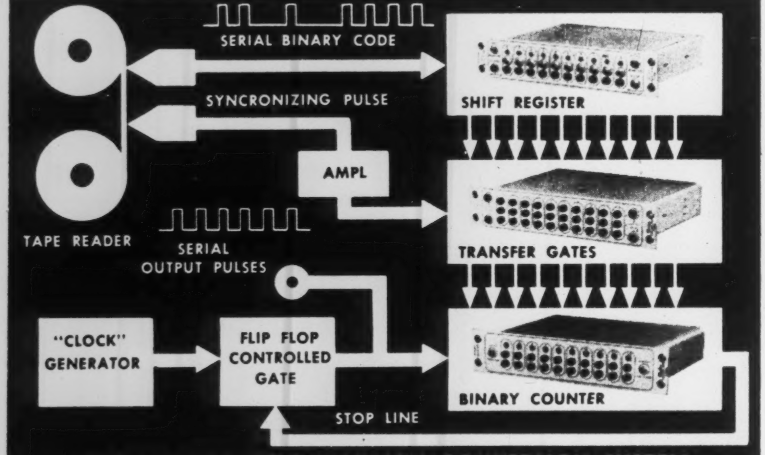

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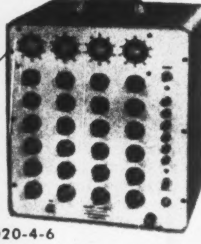

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9	29	49	69	89	109	129	149	169	189	209	229	249	269	289
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290
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14	34	54	74	94	114	134	154	174	194	214	234	254	274	294
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298
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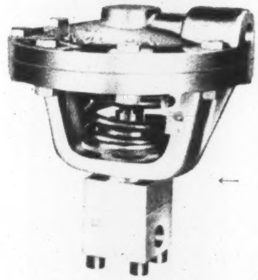
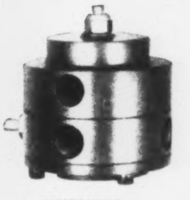


"BANTAM" 500 SERIES VALVE

Throttling "Bantam" Diaphram Control Valves for all standard control valve uses, Cv of 0.6 and below, up to 1000 psi and 500 F, characterized, renewable trim, 316 stainless steel and *Teflon* only wetted surfaces, low in hysteresis size and weight, 2000 series "Bantam" Control Valves available for on off service.



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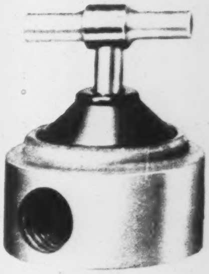

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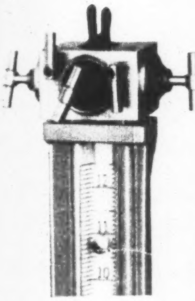

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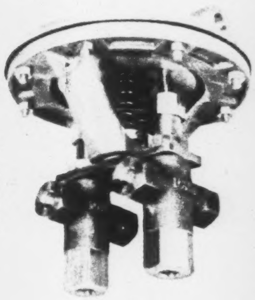

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Two valves operated simultaneously by one operator. Valves may be globe or three-way and have a multitude of piping arrangements for mixing and routing applications.

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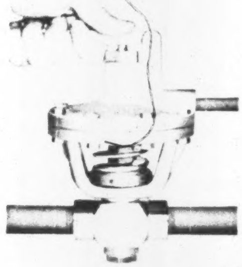

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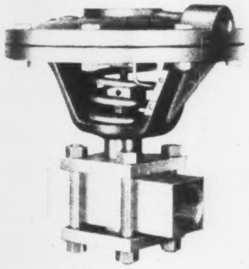

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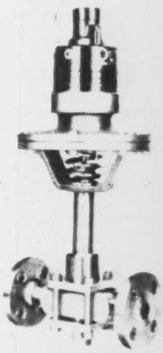

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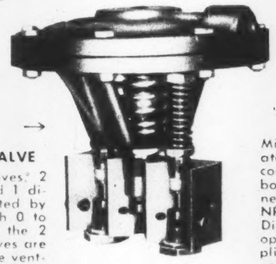

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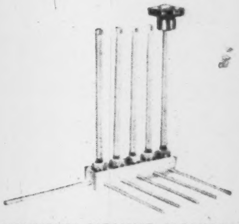

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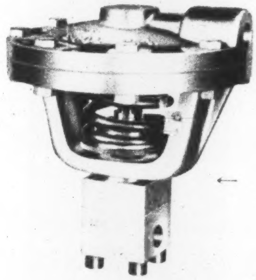

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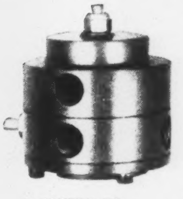

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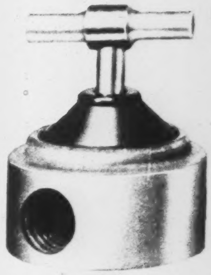

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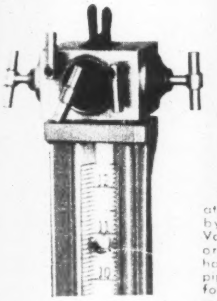

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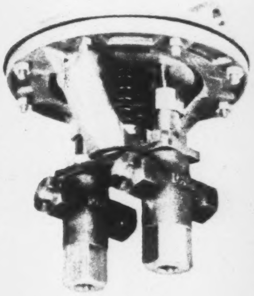

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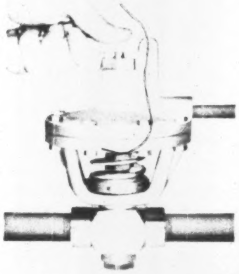

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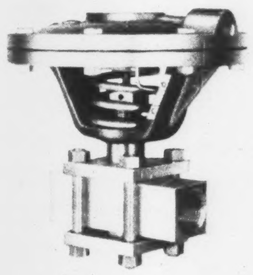

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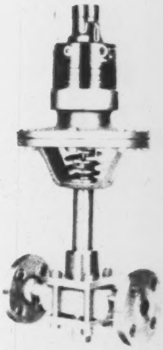

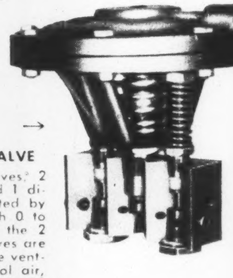

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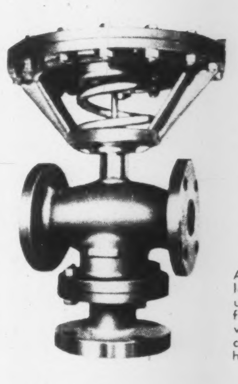

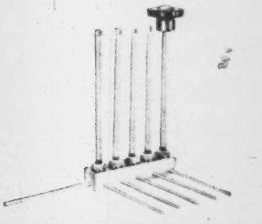

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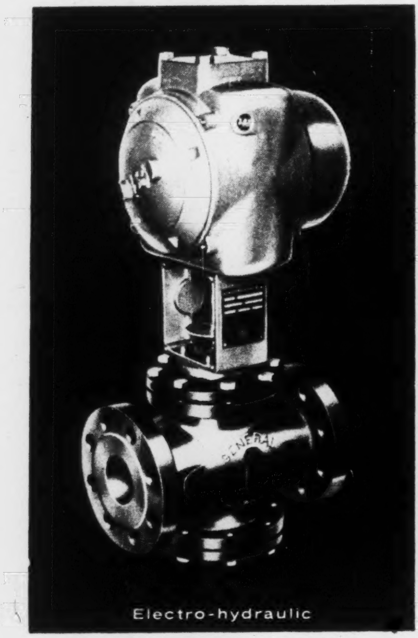

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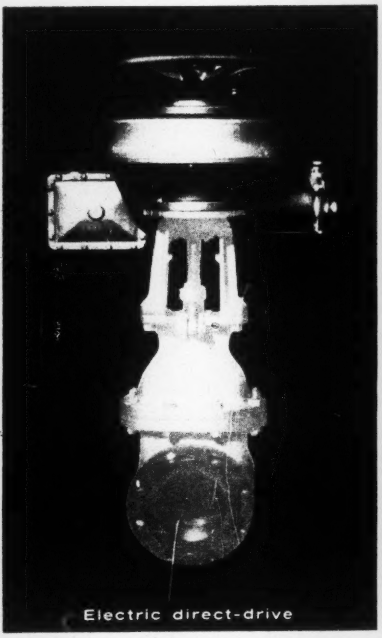

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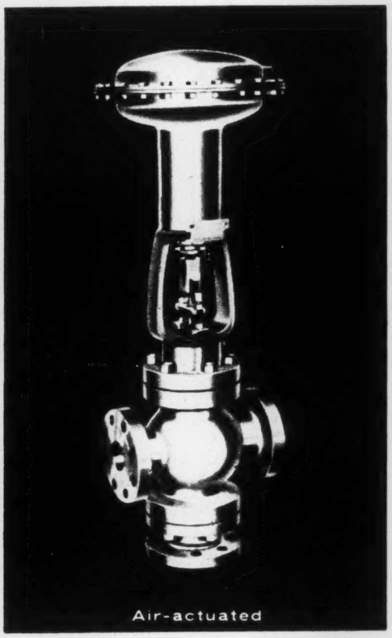

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